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**Amato et al.**

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(54) **GROWTH CONTROL DEVICE**  
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(52) **U.S. Cl.** ..... **606/280; 606/286**  
(58) **Field of Classification Search** ..... **606/280, 606/281, 286**  
See application file for complete search history.

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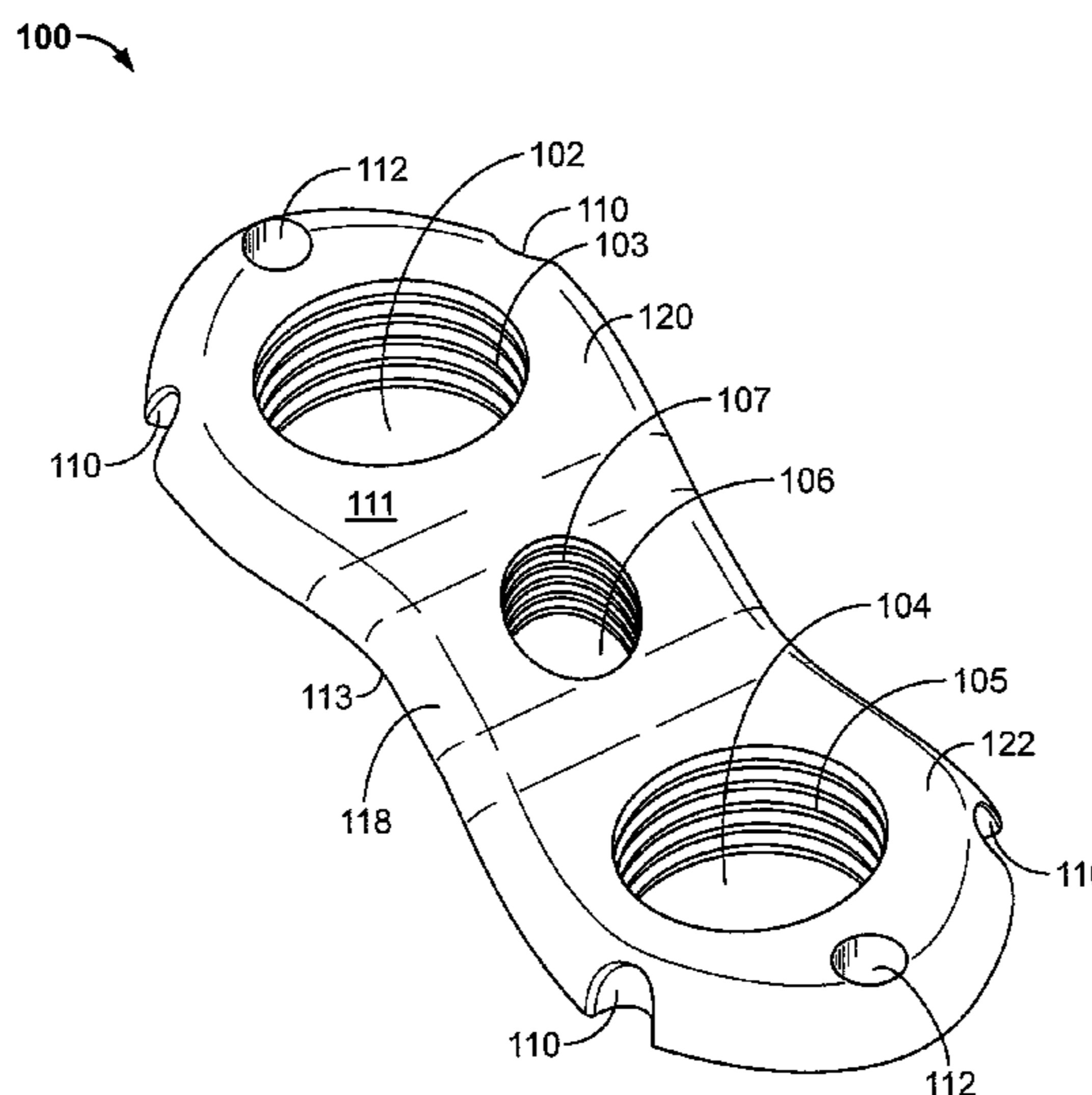
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(57) **ABSTRACT**  
A growth control device includes a bone plate having a stepped profile defined by a first level, a second level and an intermediate ramp connecting the first and second levels. The first level includes a first threaded hole for receiving a first bone fastener and the second level includes a second threaded hole for receiving a second bone fastener. The bone plate includes a proximal pair of side female notches, a distal pair of side female notches, a proximal guide hole and a distal guide hole.

**25 Claims, 16 Drawing Sheets**



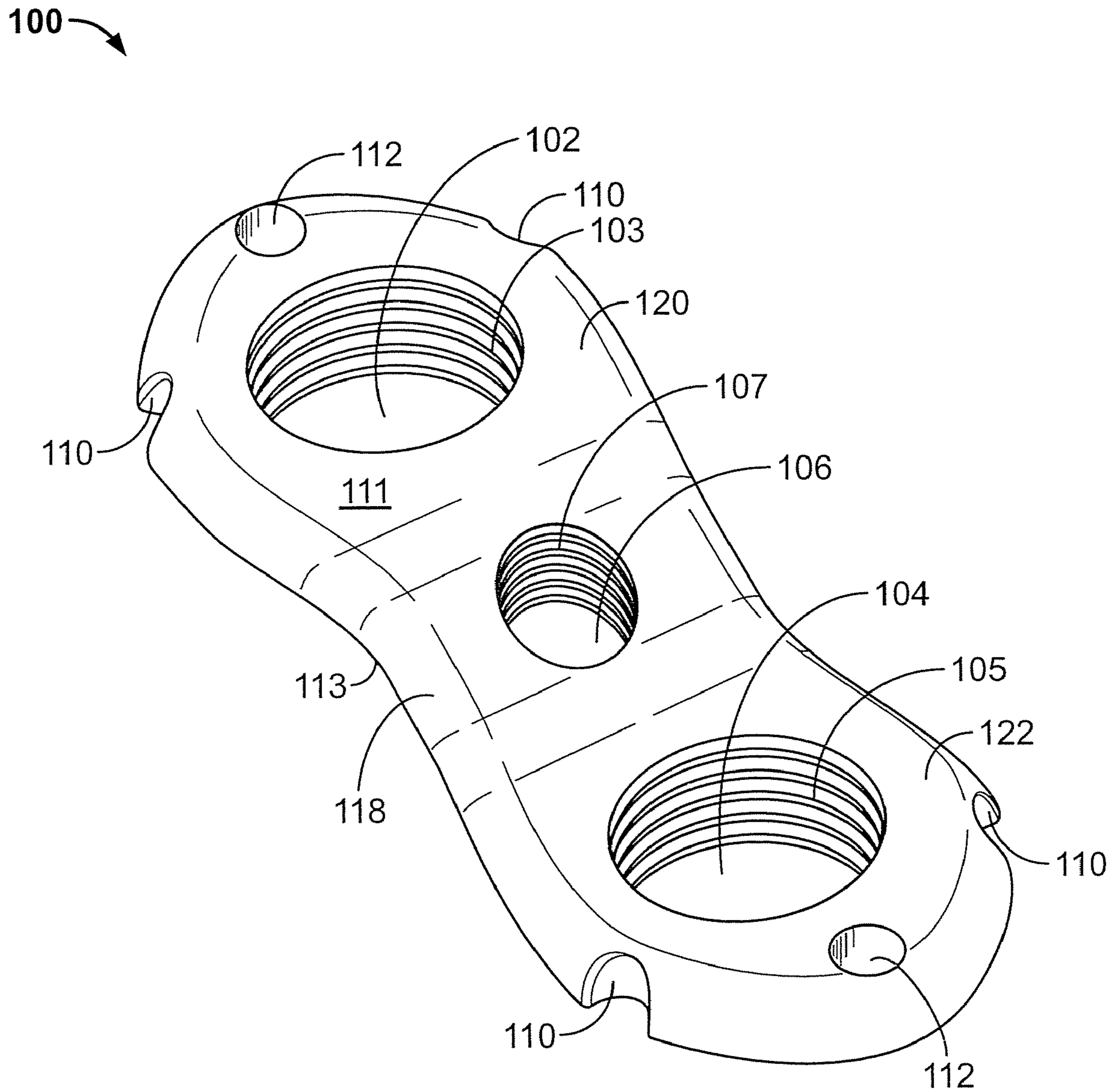


FIG. 1

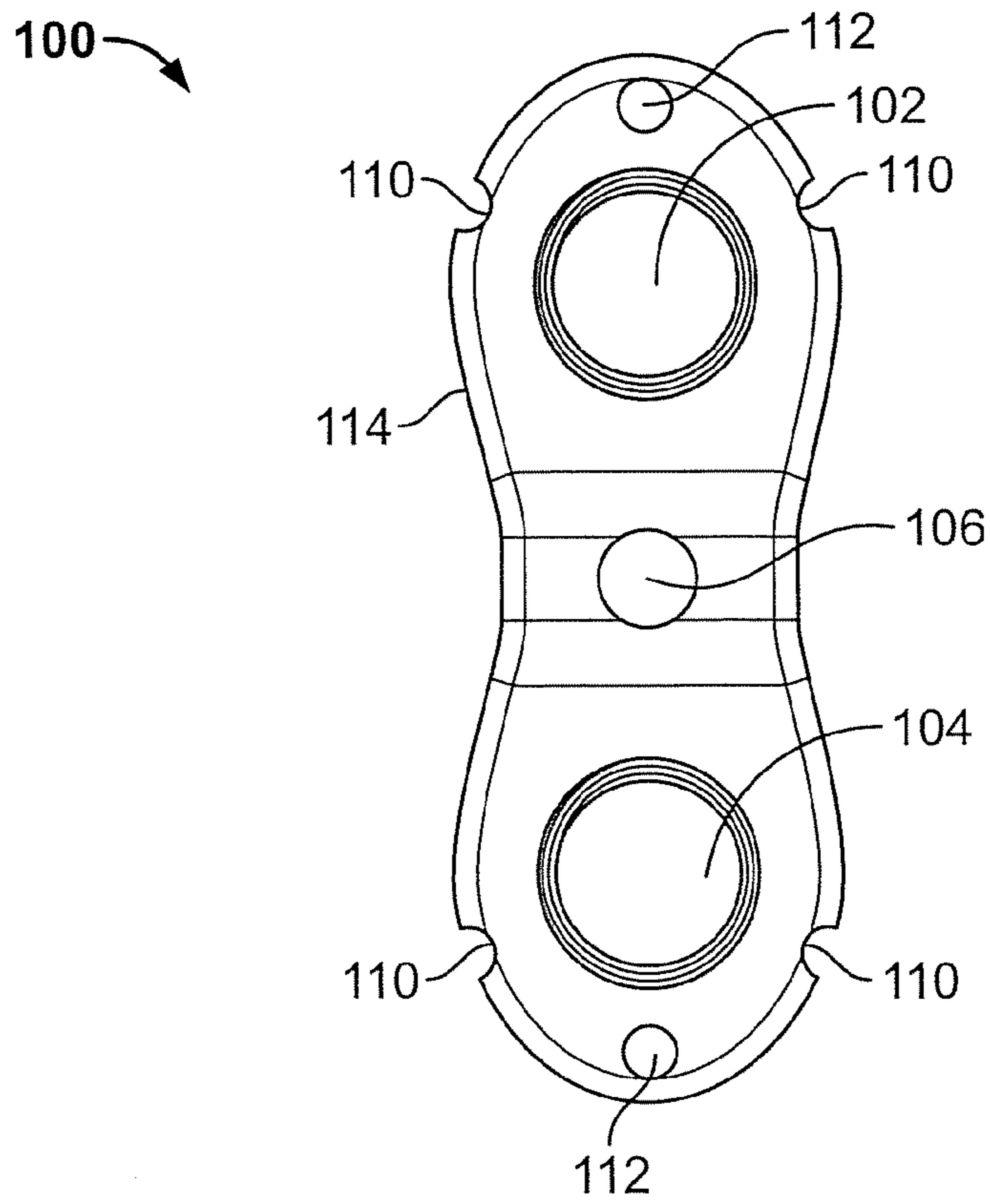


FIG. 1A

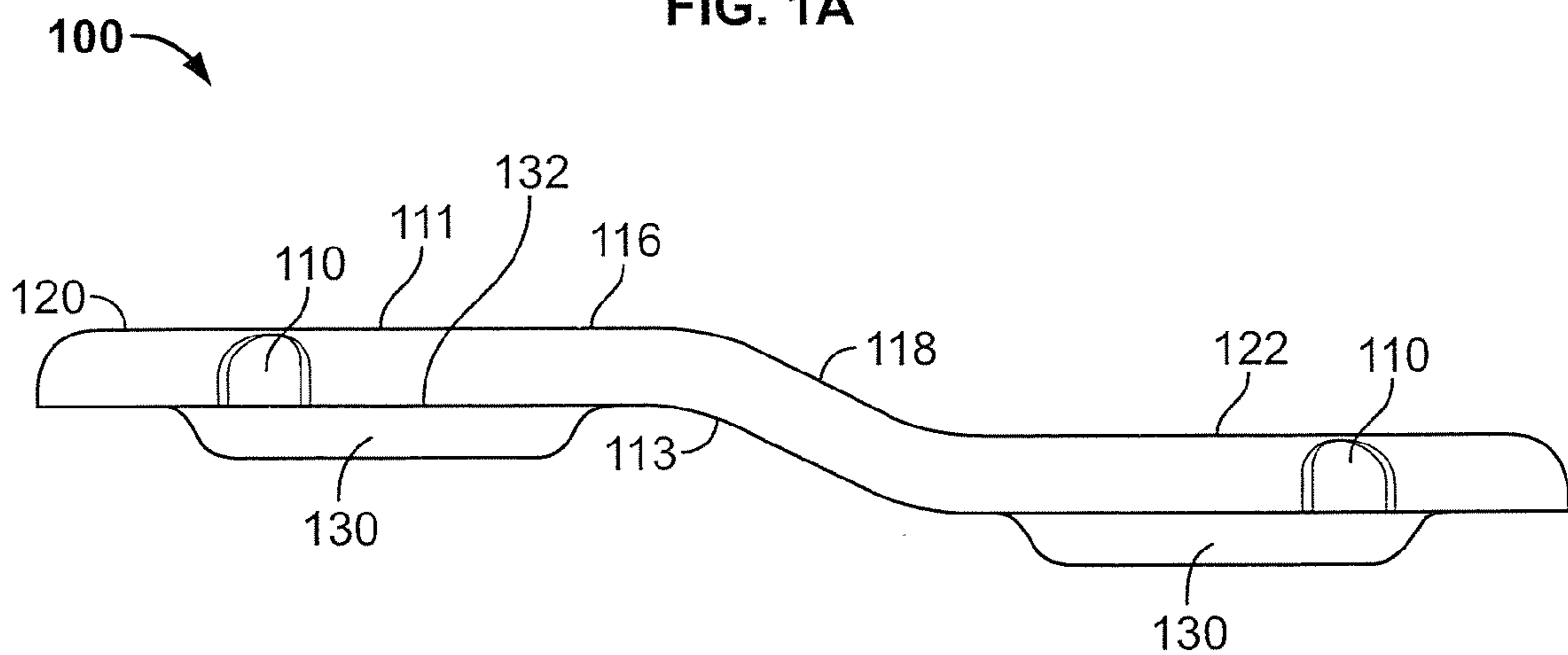


FIG. 2

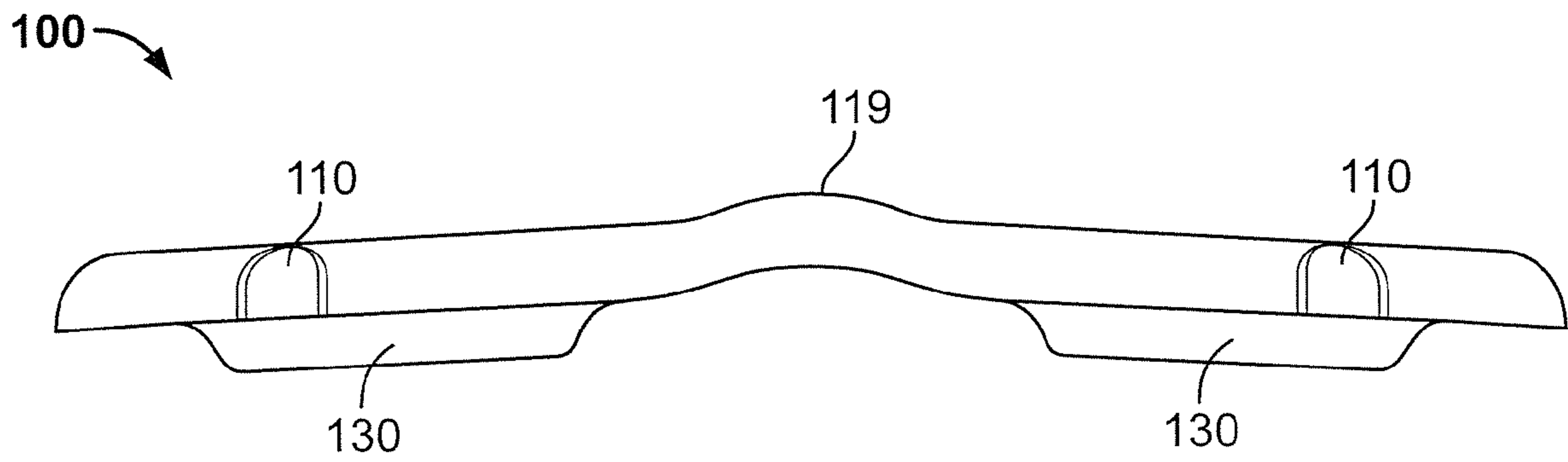


FIG. 3

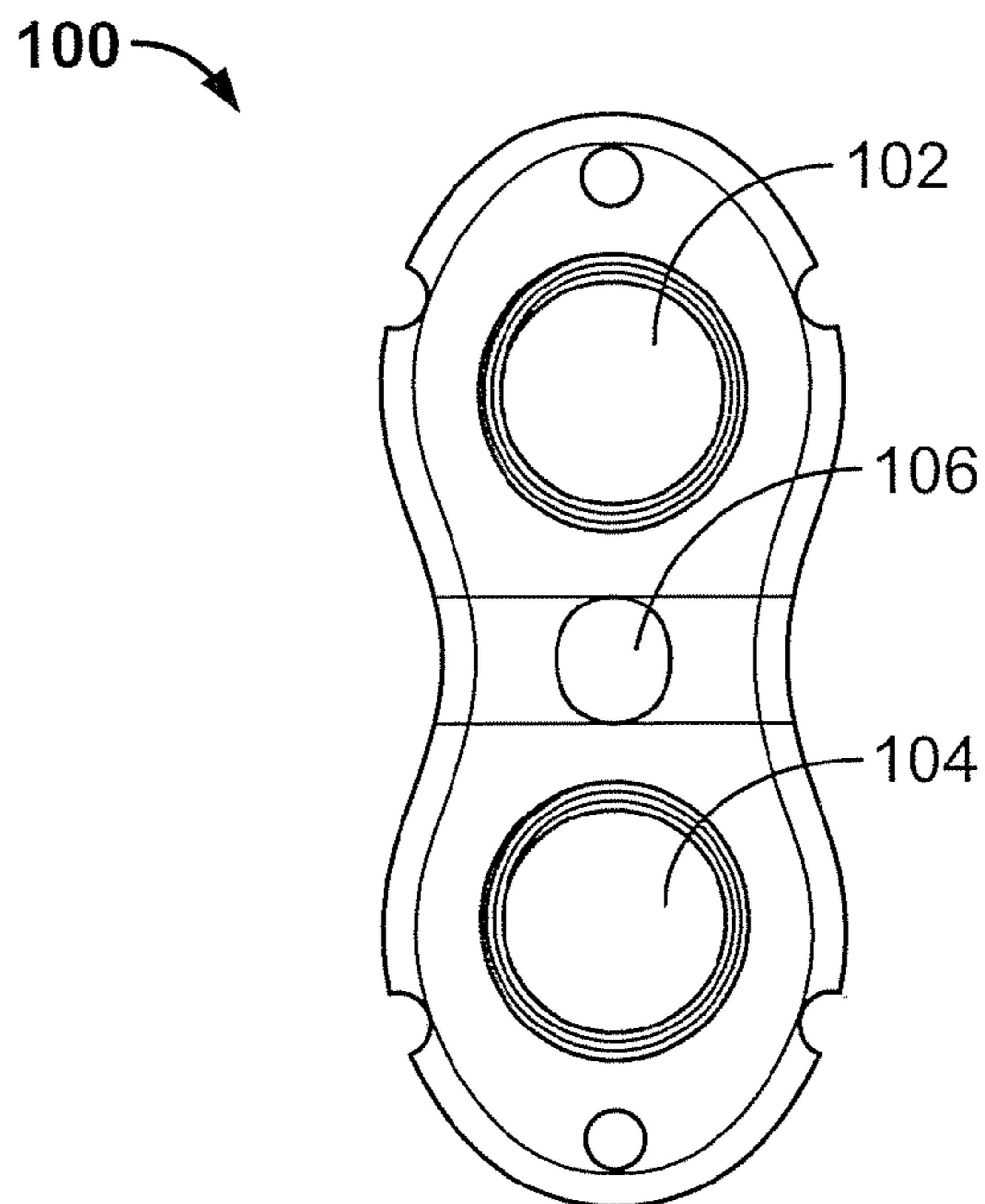


FIG. 3A

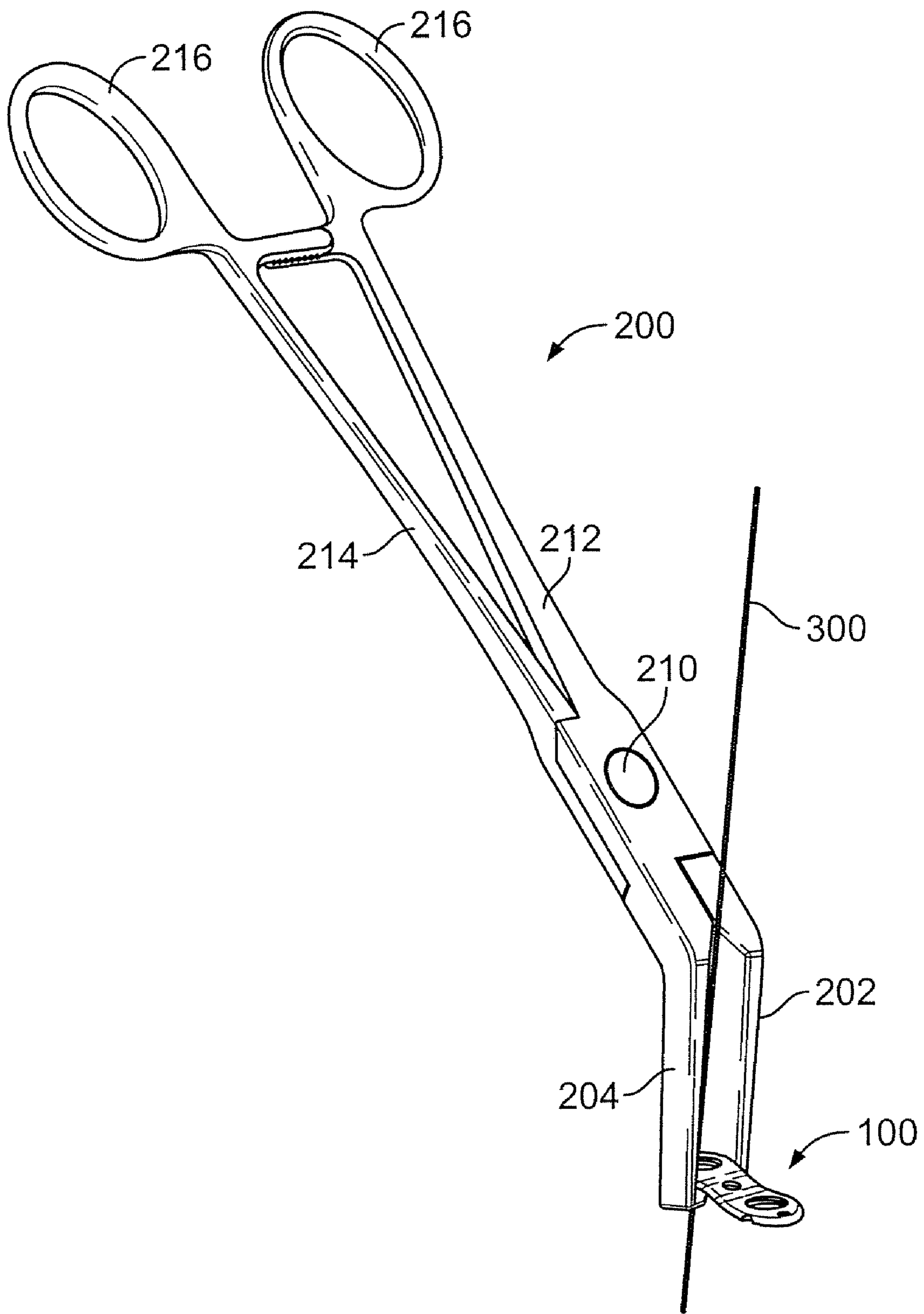


FIG. 4

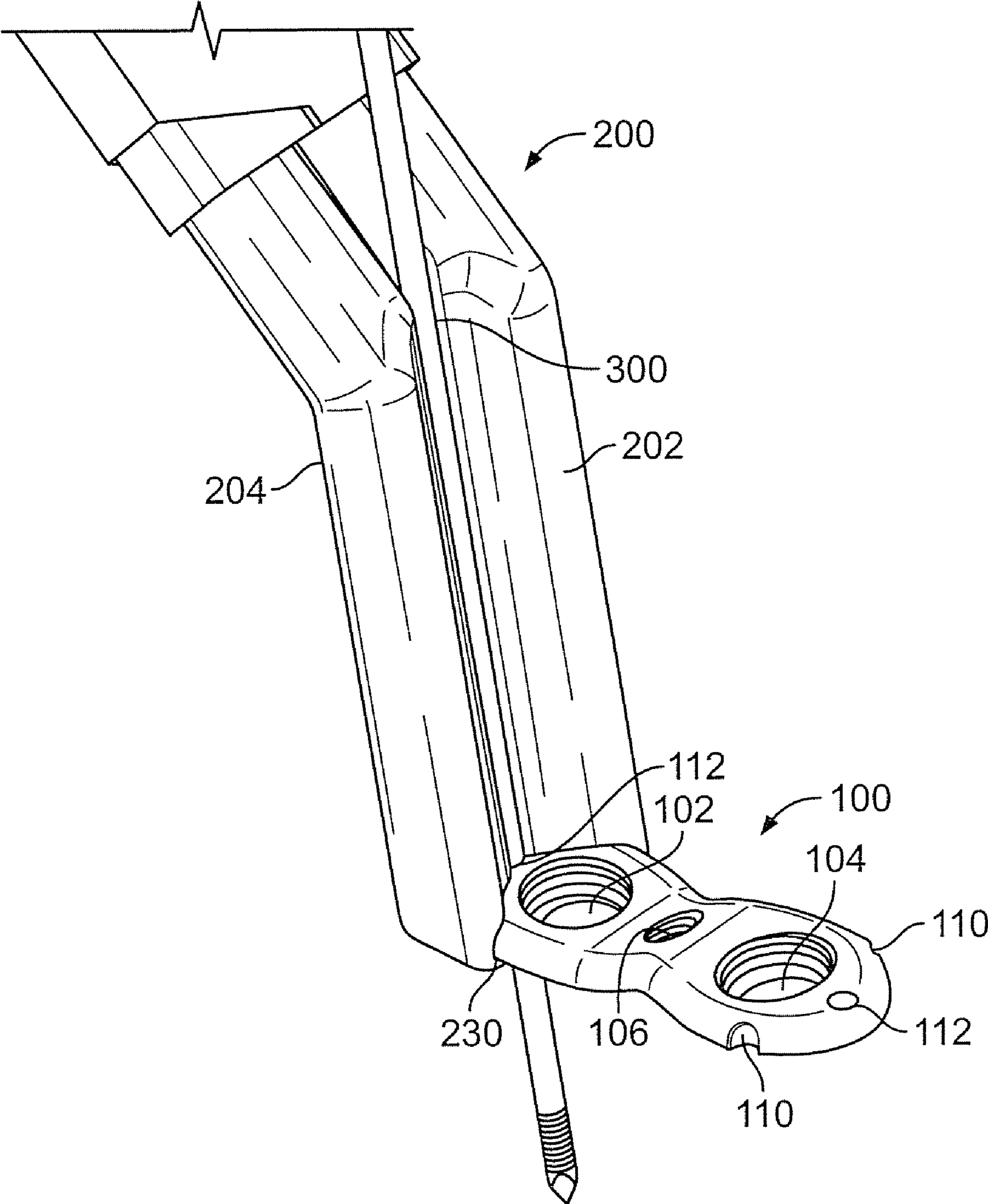


FIG. 4A

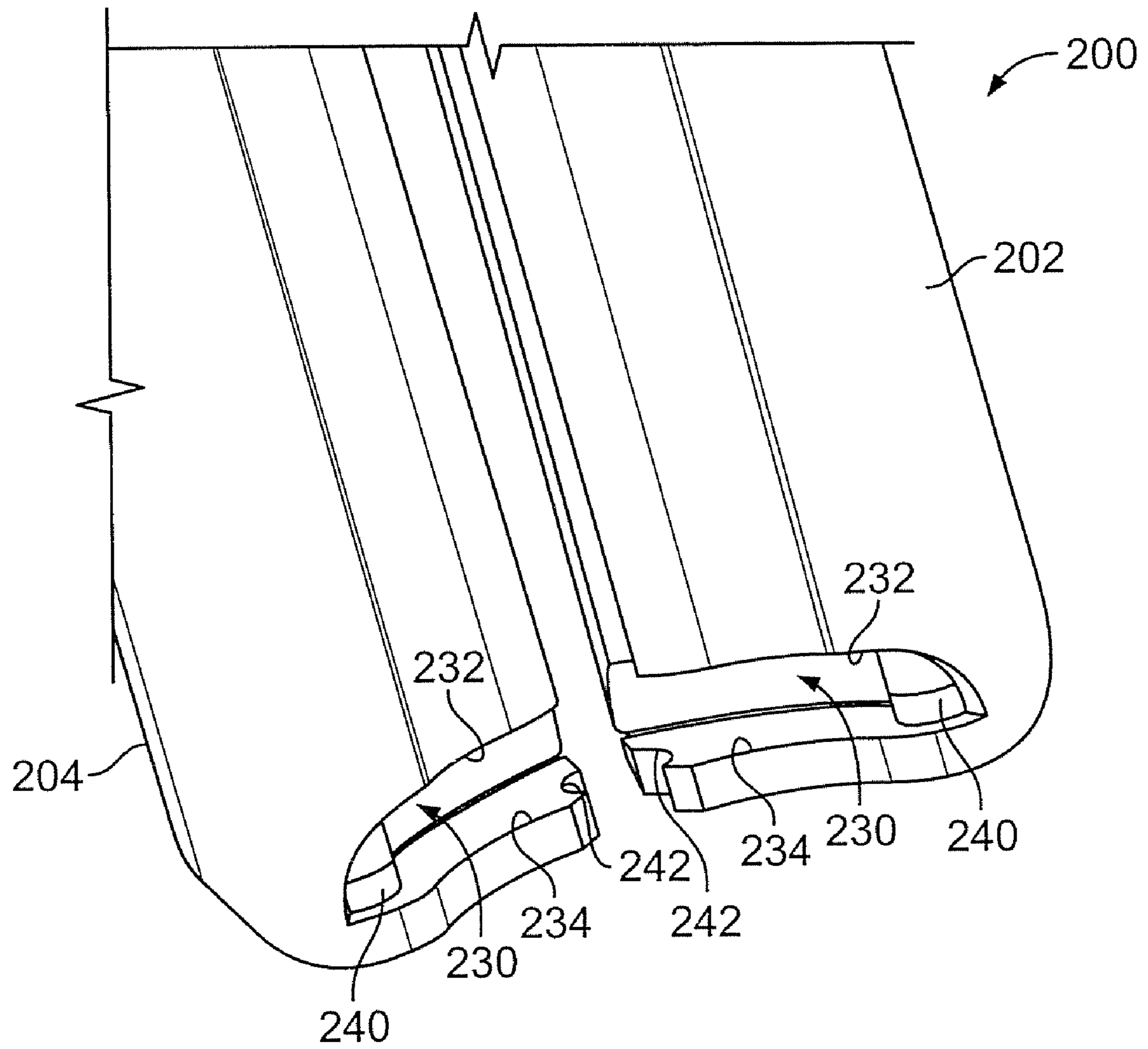


FIG. 4B

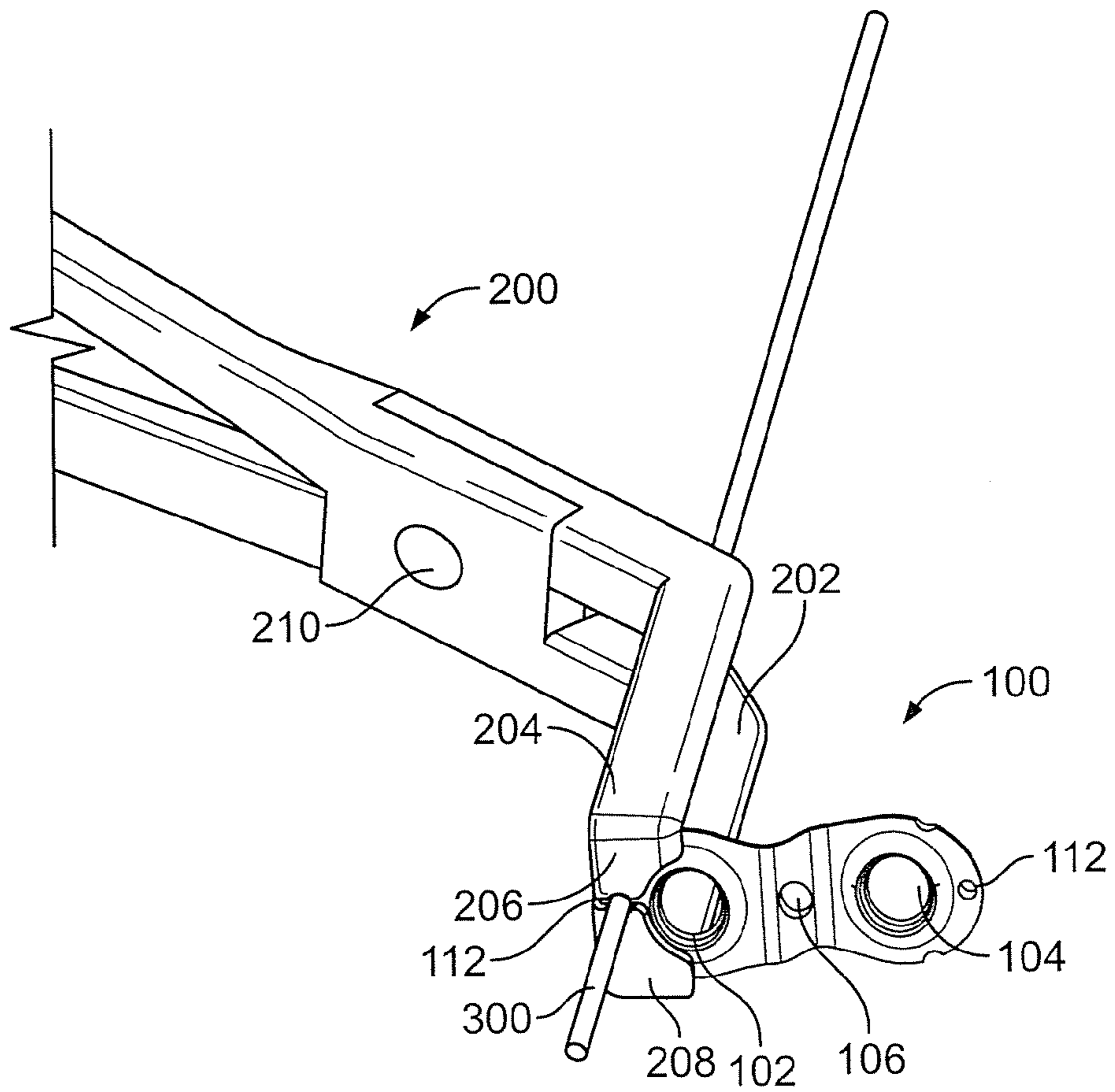


FIG. 5

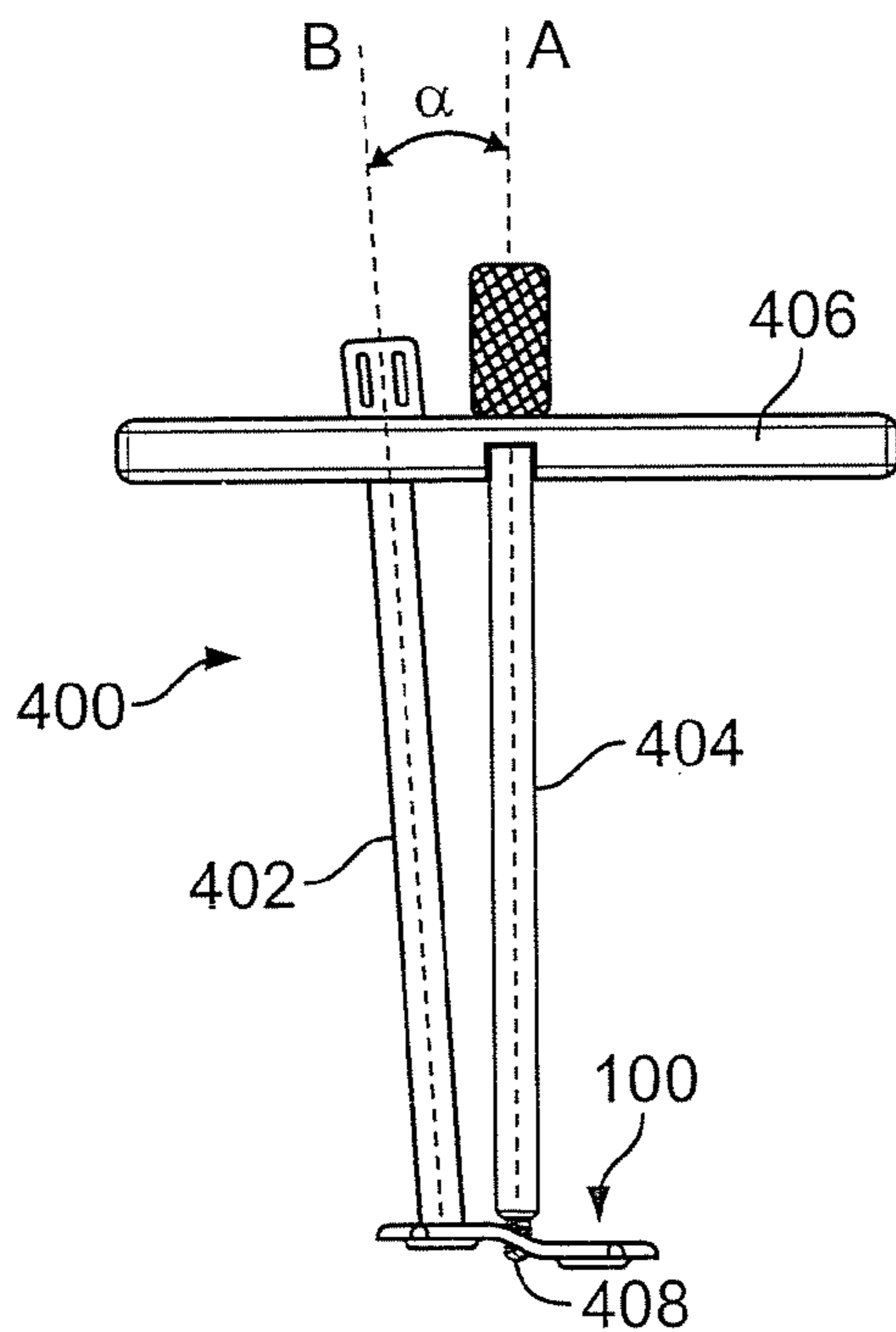


FIG. 6



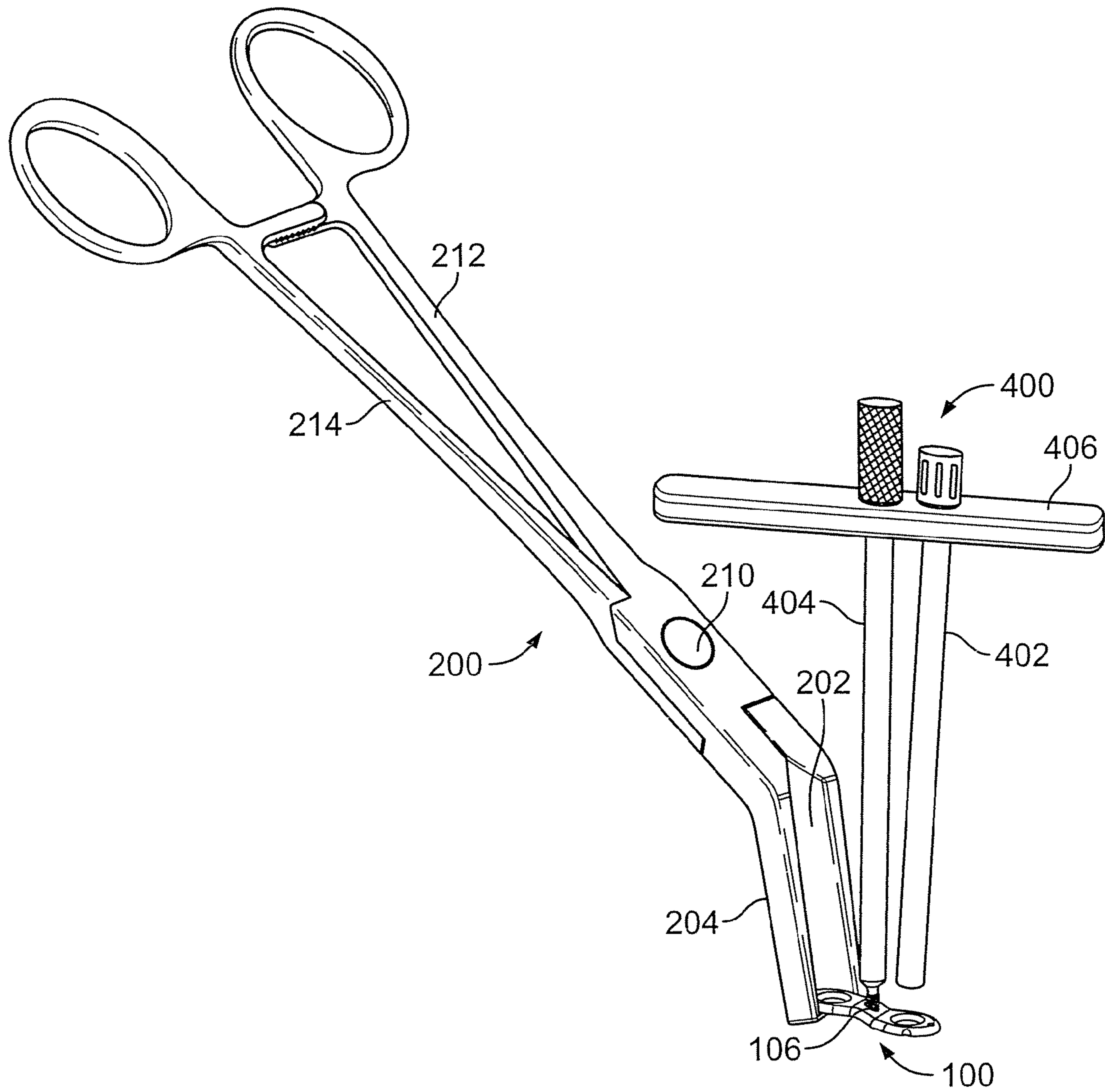


FIG. 7

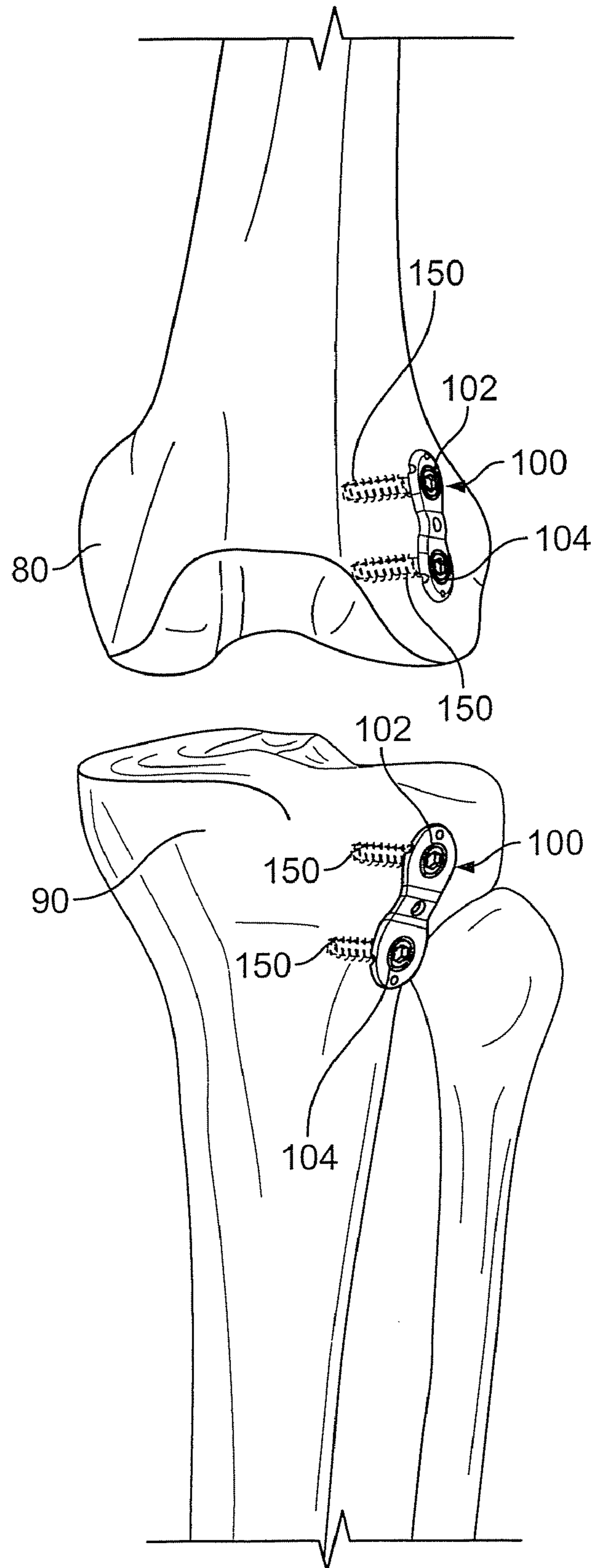


FIG. 8

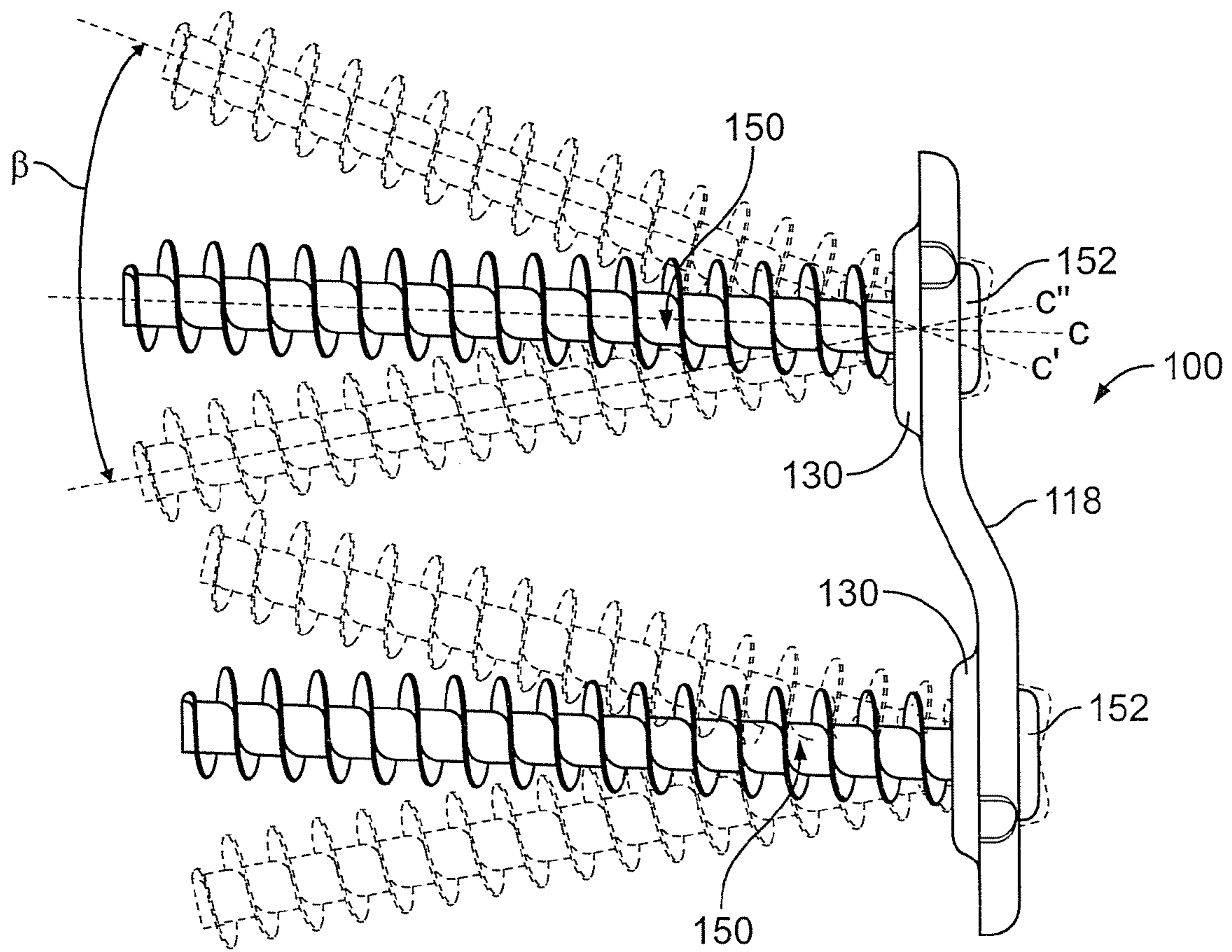


FIG. 9

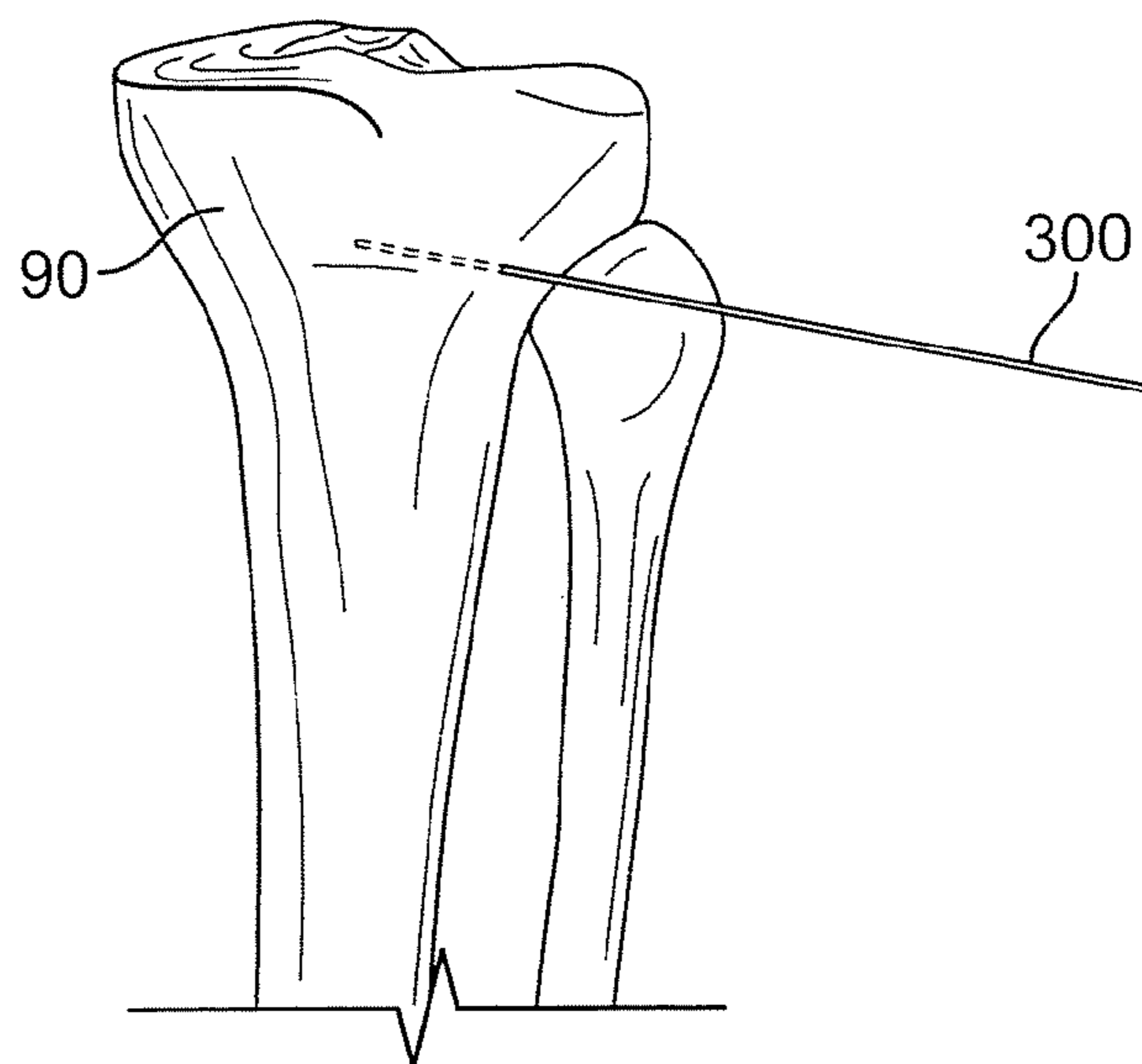


FIG. 10

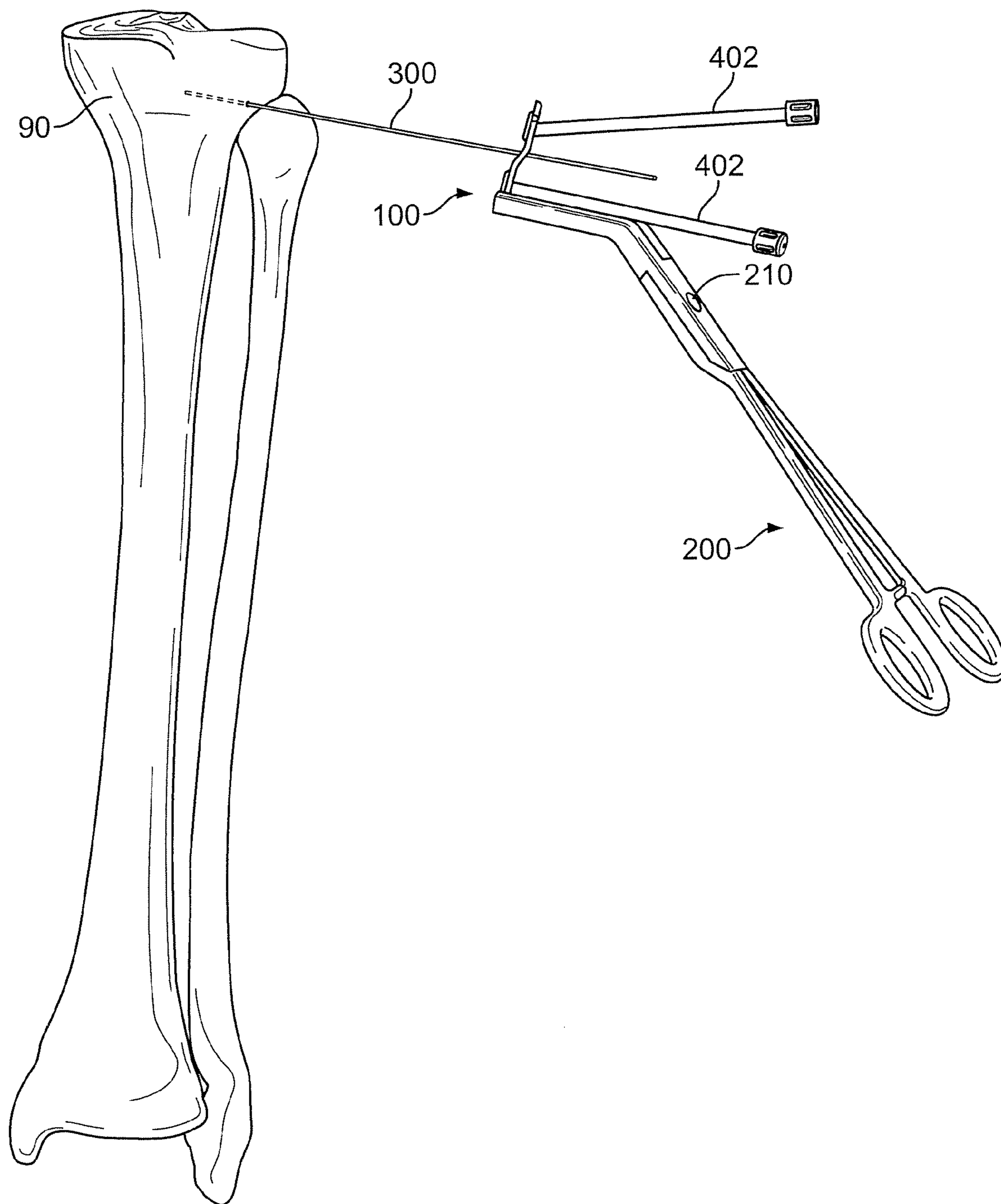


FIG. 11

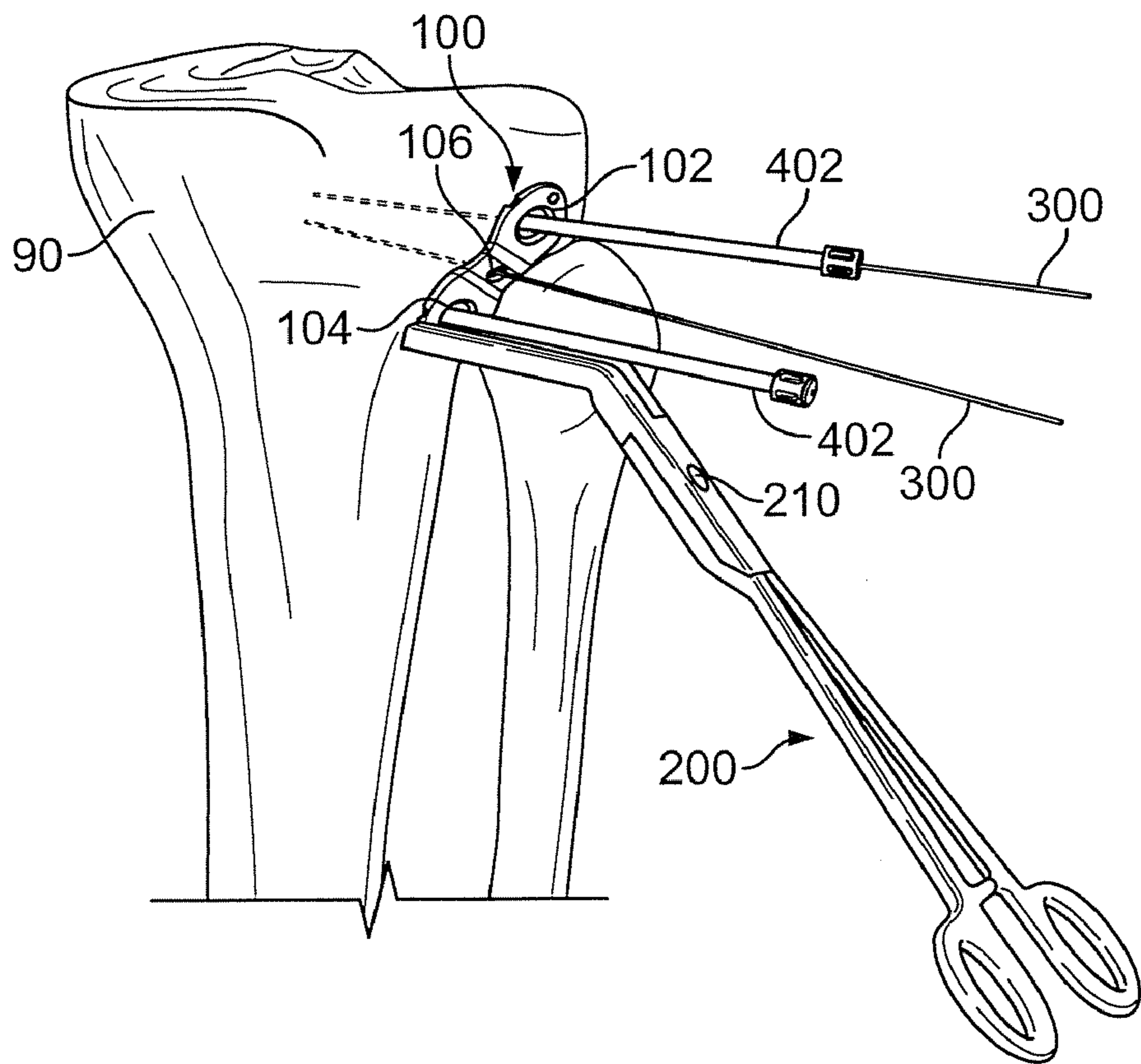


FIG. 12

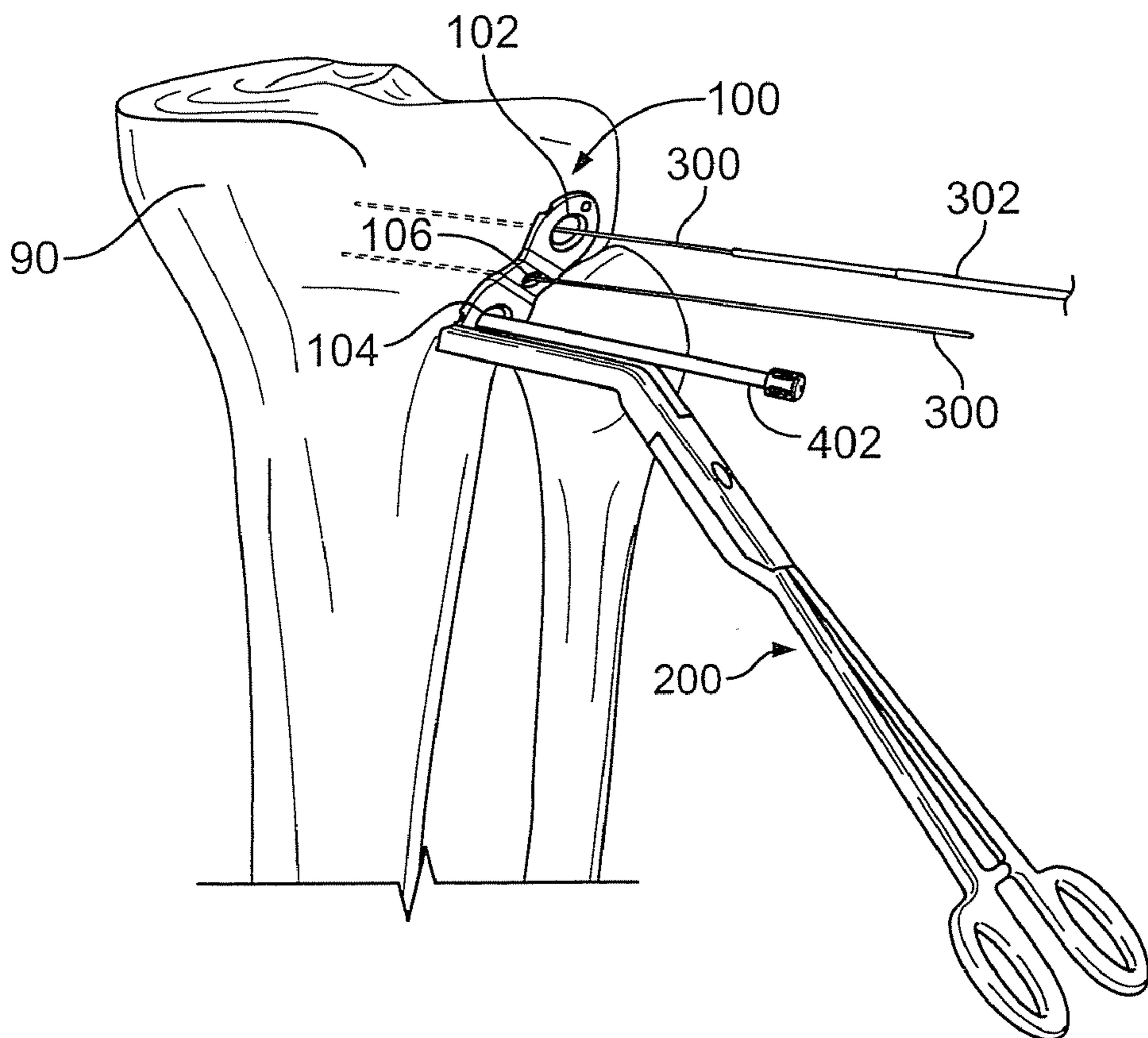


FIG. 13

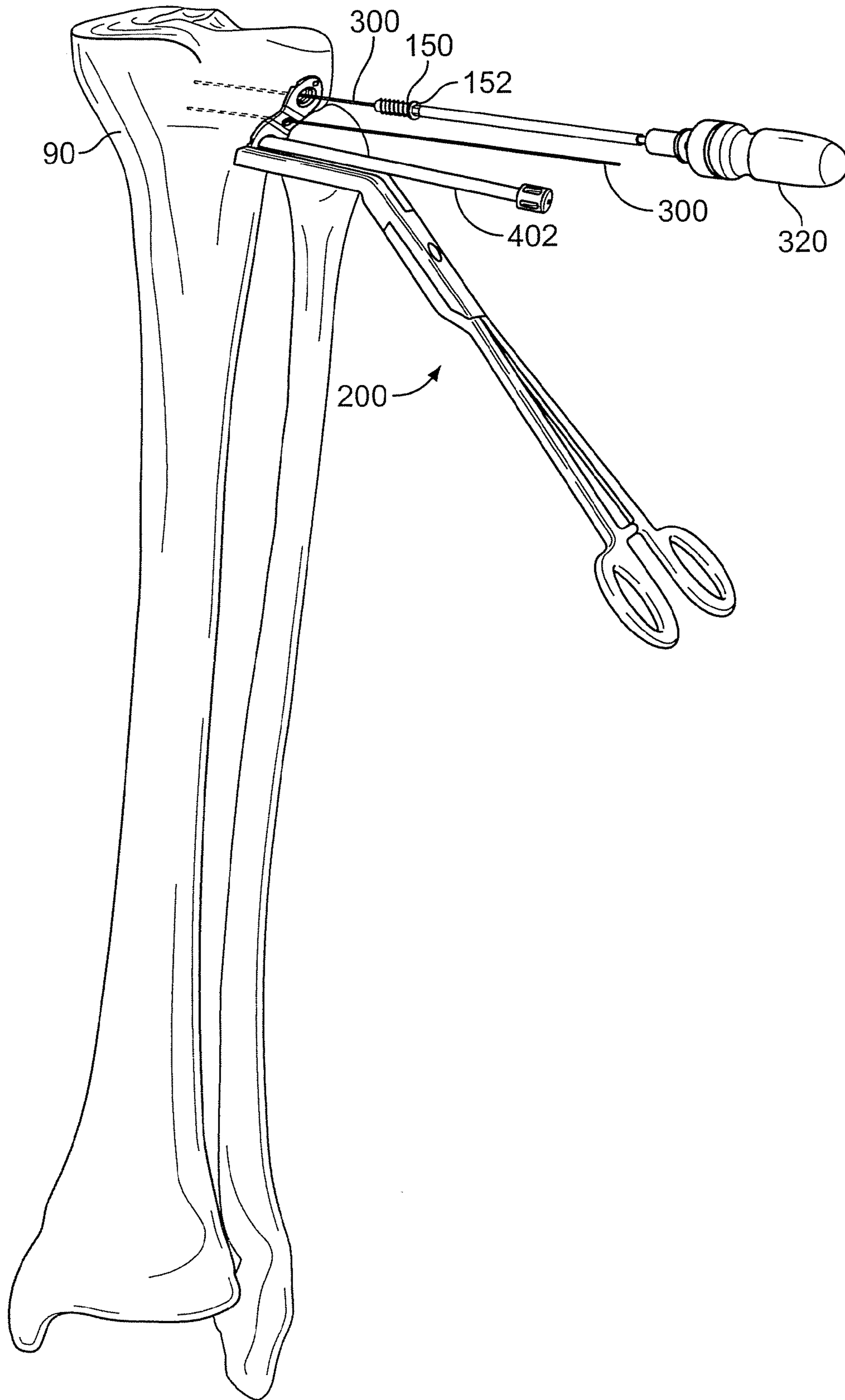


FIG. 14

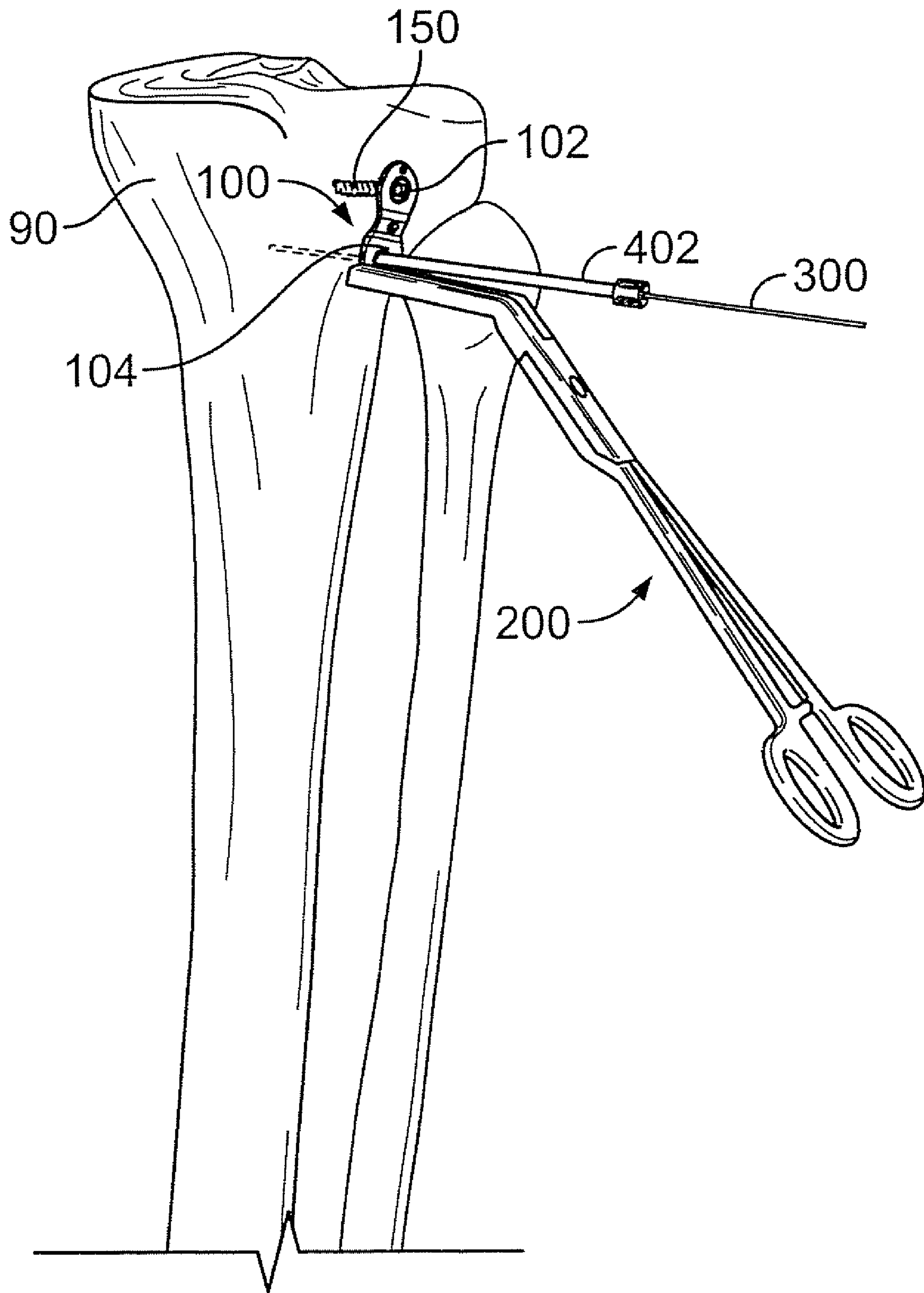


FIG. 15

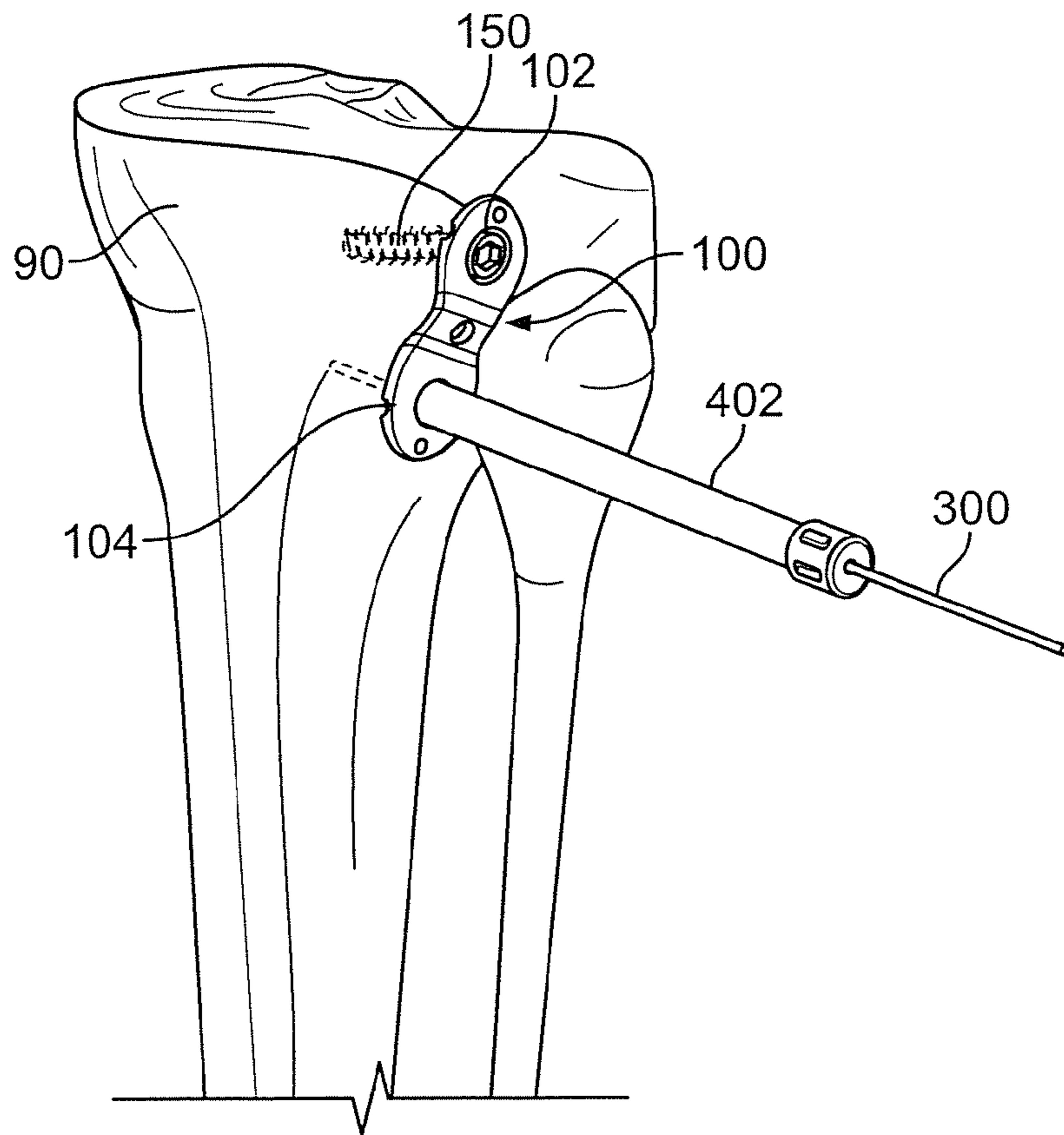


FIG. 16

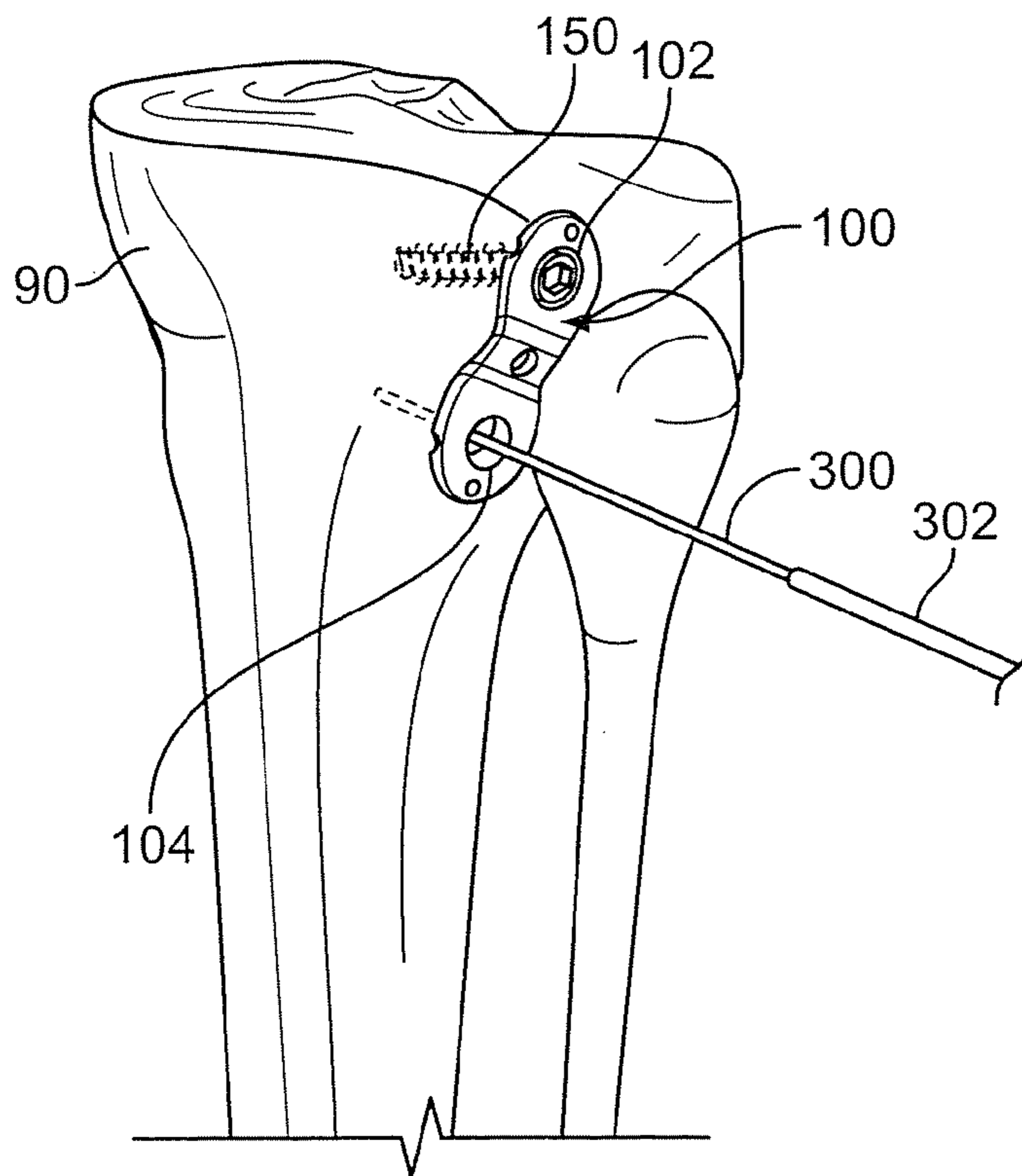


FIG. 17



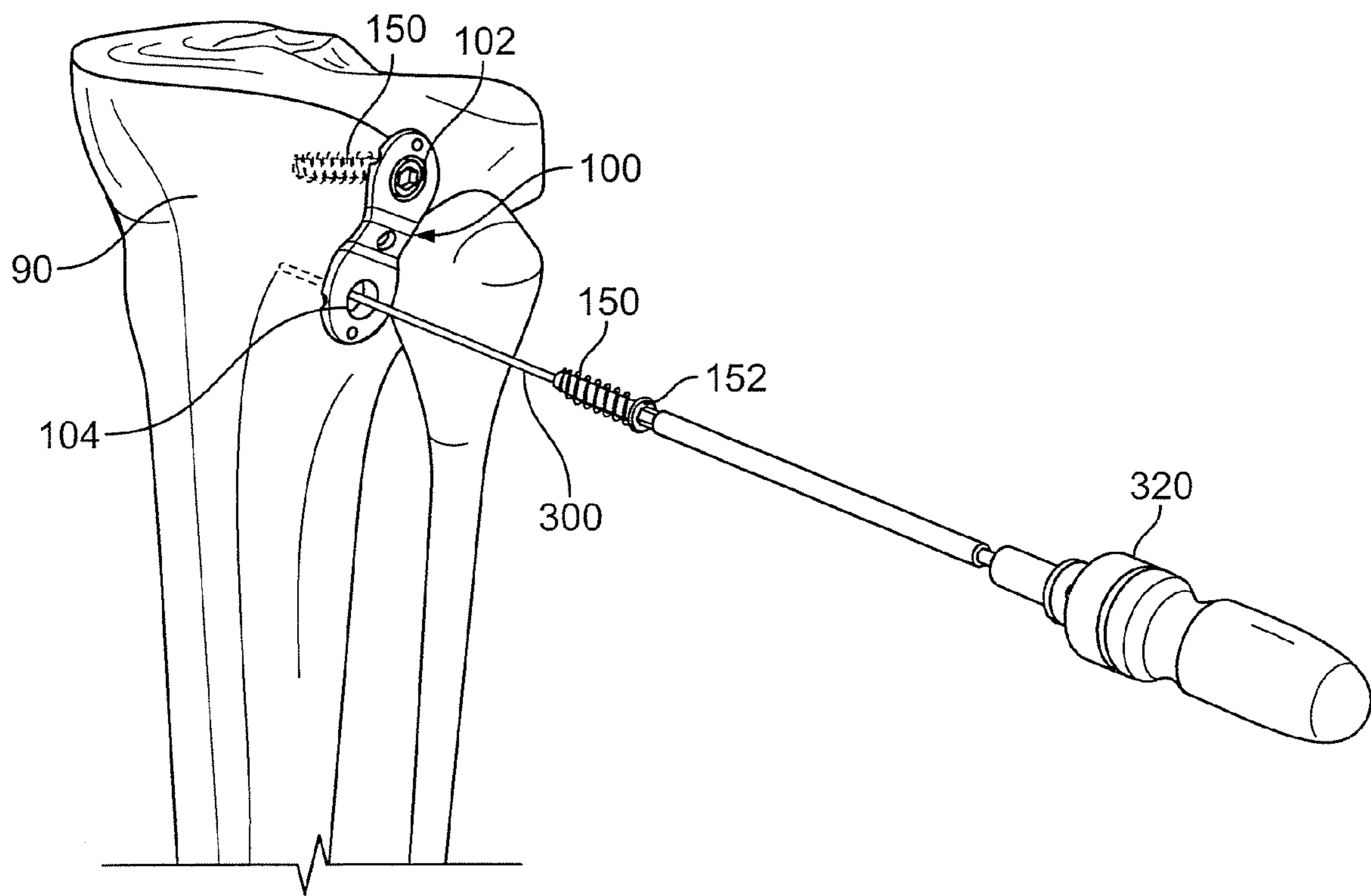


FIG. 18

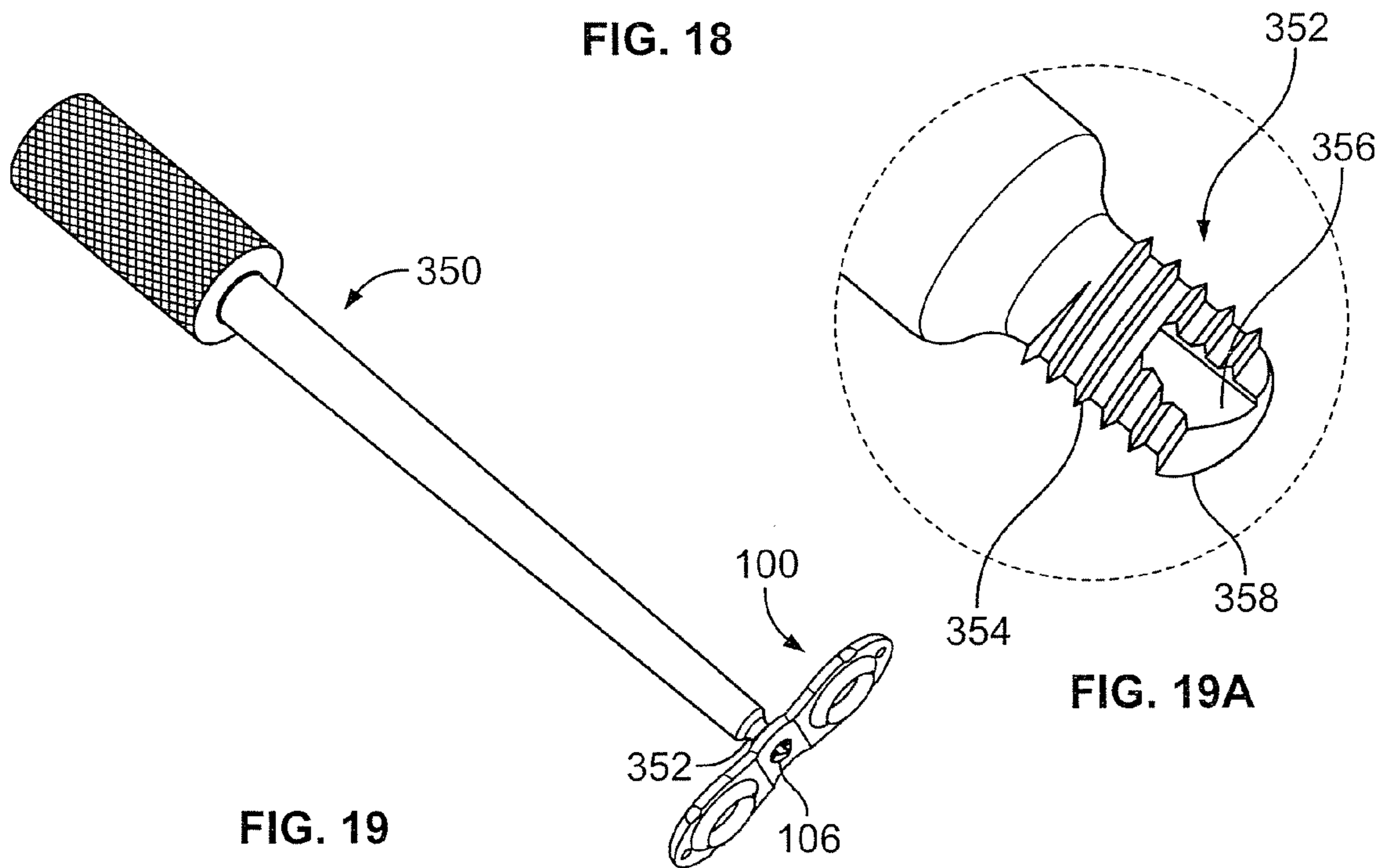


FIG. 19

FIG. 19A

## 1

## GROWTH CONTROL DEVICE

## INTRODUCTION

Various devices are known for correcting bone deformities in pediatric or other patients.

The present teachings provide a growth control device that can be used for correcting bone deformities.

## SUMMARY

The present teachings provide a growth control device. In one aspect the growth control device can include a bone plate having a stepped profile defined by a first level, a second level and an intermediate ramp connecting the first and second levels. The first level can include a first threaded hole for receiving a first bone fastener and the second level can include a second threaded hole for receiving a second bone fastener. The bone plate can include a proximal pair of side female notches, a distal pair of side female notches, a proximal guide hole and a distal guide hole.

In another aspect, the growth control device can include a bone plate as above, first and second bone fasteners receivable in the first and second holes and angulatable relative to an axis substantially orthogonal to the bone plate within a cone of angulation, and a holding device having first and second arms pivotable relative to one another, and first and second legs extending from the first and second arms. The first and second legs have first and second distal ends defining a curved split slot and a pair of male notches extending from a lower surface of the split notch, the first and second male notches engaging the first and second female notches when one of the proximal or distal ends of the bone plate is held in the curved split slot.

In a further aspect, the growth control device can include a plurality of bone plates of different sizes, each bone plate having first and second threaded holes and an intermediate portion between the first and second holes, the intermediate portion having a third threaded hole. The plurality of bone plates can include at least one stepped bone plate having an intermediated portion in the form of a ramp, and at least one arched bone plate having an intermediate portion in the form of a curved arch.

Further areas of applicability of the present teachings will become apparent from the description provided hereinafter. It should be understood that the description and specific examples are intended for purposes of illustration only and are not intended to limit the scope of the present teachings.

## BRIEF DESCRIPTION OF THE DRAWINGS

The present teachings will become more fully understood from the detailed description and the accompanying drawings, wherein:

FIG. 1 is a perspective view of a growth control device according to the present teachings;

FIG. 1A is a top view of the growth control device of FIG. 1;

FIG. 2 is an elevated side view of the bone plane of FIG. 1;

FIG. 3 is a perspective view of a growth control device according to the present teachings;

FIG. 3A is a top view of the growth control device of FIG. 3;

FIG. 4 is a perspective view of the growth control device of FIG. 1 shown with a holding device;

FIG. 4A is an enlarged detail of FIG. 4;

FIG. 4B is an enlarged detail of the holding device of FIG. 4;

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FIG. 5 is a perspective view of the growth control device of FIG. 1 shown with a holding device;

FIG. 6 is an elevated side view of the growth control device of FIG. 1 shown with a targeting device;

FIG. 7 is a perspective view of the growth control device of FIG. 1 shown with a holding and targeting devices;

FIG. 8 is an environmental view showing a growth control device implanted in the femur and a growth control device implanted in the tibia according to the present teachings;

FIG. 9 is an elevated side view of the growth control device of FIG. 1 shown with variable-angle bone fasteners;

FIGS. 10-18 are views illustrating various aspects of implanting a growth control device in the tibia with associated devices according to the present teachings;

FIG. 19 is a perspective view of a growth control device coupled to an extractor according to the present teachings; and

FIG. 19A is an enlarged detail of a distal end of the extractor of FIG. 19.

## DESCRIPTION OF VARIOUS ASPECTS

The following description is merely exemplary in nature and is in no way intended to limit the present teachings, applications, or uses. For example, although the present teachings are illustrated for procedures relating to femur and/or tibia, the present teachings can be used for any long bones in pediatric or other surgery. In particular, the present teaching can be used to correct angular deformities in long bones in pediatric patients.

Referring to FIGS. 1-8, various aspects of exemplary growth control devices according to the present teachings is illustrated. The growth control device can include one or more bone plates 100. A bone plate 100 can have an anatomically contoured stepped or offset profile, as illustrated in FIGS. 1, 1A and 2, or an anatomically contoured humped or arched profile, as illustrated in FIGS. 2 and 3. An environmental view of anatomically contoured bone plates 100, as implanted in the femur 80 and tibia 90 according to the present teachings, is illustrated in FIG. 8.

Generally, the growth control device can be used to provide gradual correction of an angular deformity in a long bone by restraining one side, medial or lateral, of the growing bone, causing the bone to grow on the opposite side, thereby forcing a natural correction by a non-symmetric corrective bone growth. Further, as illustrated in FIG. 8, the growth control device can include a bone plate 100 which is contoured and profiled for matching the anatomy of the particular bone, and non-locking threaded bone fasteners 150 that can angulate about an axis C perpendicular to the bone plate 100 within a cone of maximum angulation of an angle  $\beta$  of about 32-degrees between axes C' and C", as shown in FIG. 9. Each bone fastener 150 can be cannulated therethrough for receiving a guide wire 300, and can have a spherically shaped head 152 including a formation for engaging a driver 320, as shown in FIG. 18. The bone fasteners 150 can be low-profile cannulated titanium alloy screws with self-cutting tips and reverse buttress threads to guard against pull out.

More specifically, and referring to FIGS. 1, 1A and 2, the bone plate 100 can have, in a side elevated view, a stepped profile 116 that includes a first level 120, a second level 122 and an intermediate inclined or ramped portion 118 connecting the first level 120 to the second level, as shown in FIG. 2. The profile 116 can be shaped to conform to the anatomic contour of a long bone of a patient and can be provided in various sizes and shapes, including the relative dimensions of the first level 120, the second level 122 and the intermediate

portion **118**, to account for anatomic differences from bone to bone and from patient to patient, including patient's age, gender, and degree of deformity. The first level **120** and the second level **122** can be disposed in parallel and spaced apart planes.

Referring to FIGS. **1-2**, **4-7**, **19**, and **19A**, the bone plate **100** can include first and second (proximal and distal) holes **102**, **104** extending through the thickness of the bone plate **100** from an outward or upper surface **111** to an opposite bone-engaging surface **113**. The holes **102**, **104** define corresponding inner surfaces **103**, **105**, which are threaded and spherically shaped for receiving threaded fixation bone fasteners **150** having spherically shaped heads **152**, as shown in FIG. **9**. The bone plate **100** can also include a third or central hole **106**, positioned between the first and second holes **102**, **104**. The third hole **106** can define a threaded inner surface **107** for engagement with a threaded distal end **408** of a post **400** of a targeting device and/or a threaded distal end **352** of an extractor **350**, as shown in FIGS. **6**, **7** and **19**. Further, the bone plate **100** can include two smaller end openings or guide holes **112** at the proximal and distal ends of the bone plate **100** for guiding a K-wire or other guide wire **300** therethrough, as shown in FIG. **5**, for example. The bone plate **100** can also include two pairs of female side notches **110**, i.e., medial and lateral notches **110** at the proximal and distal ends of the bone plate **100**, for engagement with forceps or other holding device **200**, as shown in FIGS. **4**, **4A**, **4B**, for example, and described below.

Referring to FIG. **2**, the bone plate **100** can include first and second washers **130** surrounding the first and second holes **102**, **104** on the bone engaging surface **113** of the bone plate **100**. Each washer **130** can be unitarily integrated and built-in the bone plate **100** forming a unitary device with the bone plate **100**. The washers **130** can provide a clearance for the physis of the bone and reduce contact with the periosteum of the bone.

In another aspect, and referring to FIGS. **3** and **3A**, a bone plate **100** having an intermediate portion **119** in the form of an arch or hump, rather than an offset ramp, can be used depending on the anatomical contour of the specific patient or long bone. The intermediate portion **119** avoids placing bearing load on the physis of the bone or injuring the physis during the correction period, when the bone plate **100** is implanted in a pediatric patient for correcting a non-symmetric growth or other unequal bone growth or deformity. In other respects, the bone plate of FIGS. **3** and **3A** is similar to bone plates of FIGS. **1-2**.

The profile **116** of ramped bone plate **100** of FIG. **2** can match the anatomical features of the proximal tibia **90** before the bone fasteners are implanted through the bone plate **100**. Further, the ramped profile **116** allows parallel placement of bone fasteners **150** through the holes **102**, **104** of the bone plate **100**, as shown in FIG. **8**. Gradual angulation of the bone fasteners **150** relative to the bone plate **100** occurs over a longer period of time before reaching the maximum angulation of the growth control device. The extended period to maximum angulation can reduce the risk of bone fastener fracture, which can be greater when maximum angulation of the bone fastener **150** is reached such that the growth control device of the bone plate **100** and the bone fasteners **150** becomes substantially rigid while bone growth continues.

The combination of the stepped profile **116** and other features of the bone plate **100** of FIG. **2** with the ability of the bone fasteners **150** to angulate relative to an axis **C** perpendicular to the bone plate within a cone of angulation of an angle  $\beta$  can provide deformity correction during the physis

growth period without closing the physis or completely preventing growth until maximum angulation is reached.

Various devices can be used for implanting the bone plate **100** and the bone fasteners **150**, for interoperative manipulation of the bone plate **100** and for bone plate extraction. Referring to FIGS. **4**, **4A**, **4B** and **5**, a holding device **200** for the bone plate **100** in the form of forceps is illustrated. The holding device **200** has scissor-like gripping handles **216**, first and second arms **212**, **214** pivotably coupled with a pivot pin **210**, and first and second legs (forceps tips) **202**, **204** configured for holding the bone plate **100** from one end, and capturing a guide wire **300** that can pass through the corresponding end opening **122** of the bone plate **100**. The distal ends of the forceps legs **202**, **204** define a split curved groove or slot **230**, in the form of a pair of slots **230**, between corresponding upper and lower surfaces **232**, **234**. A pair of male notches or press pins **240** extend from the lower surface **234** substantially perpendicularly to the lower surface **234** and up to or stopping just short of the upper surface **232** of the slot **230**. The split slot **230** is shaped to receive either end of the bone plate **100**, such that the pins **240** engage the side notches **110** of the bone plate **100**. The pins **240** can secure the bone plate **100** to the holding device **200** and prevent unintentional shifting of the bone plate **100** during tightening of the bone fasteners **150**. The distal ends of the legs **202**, **204** also define a split guiding bore **242** for receiving the guide wire **300** that passes through the end hole **112** of the bone plate **100** and between the legs **202**, **204** of the forceps when the bone plate **100** is held in the slot **230** of the forceps **200**, as shown in FIGS. **4A** and **4B**. The first and second legs **202**, **204** of the holding device **200** can be contoured and cooperate with the split guiding bore **242** to provide an integrated guide for the guide wire **300** along the length of the legs **402**, **404**, as shown in FIG. **4A**.

Referring to FIGS. **6** and **7**, a targeting device **400** can be used for guiding the angulating bone fasteners **150** through the bone plate **100**. The targeting device **400** can include a support bar or plate **406** having openings for receiving a support post **404** along an axis **A** and a tubular or cannulated drill guide **402** along an axis **B** at an angle  $\alpha$  of about 16 degrees relative to the axis **A**, corresponding to a cone of maximum angulation of 32 degrees. The drill guide **402** can include a proximal end with an engagement formation for driver-assisted placement. The support post **402** can have a threaded distal end **408** threadably engaging the threaded third hole **106** of the bone plate **100**. The extractor **350** illustrated in FIGS. **19** and **19A** can be used as the support post **402**. The targeting device **400** can be used with the holding device as shown in FIG. **7**.

The growth control device can be provided in the form of a surgical kit including a plurality of bone plates **100** of different sizes and geometries with an arched intermediate portions **119** or a ramped intermediate portion **118**, a holding device **200**, a targeting device **400** with different size drill guides **402**, a plate extractor **350**, various guide wires **300** and drill bits and other instruments, such as an impact trocar, a ratcheting wrench, a torque driver, and the like.

Referring to FIGS. **10-18**, an exemplary surgical procedure for implanting the growth control device is illustrated. Referring to FIG. **10**, a guide wire **300** can be inserted in the physis (growth plate) of the tibia **90**. The bone plate **100**, as held by the holding device **200** and with proximal and distal drill guides **402** engaging the corresponding first and second holes **102**, **104** of the bone plate **100**, can be passed over the guide wire **300**, such that the guide wire **300** passes through the third hole **106** of the bone plate, as shown in FIGS. **11** and **12**. Alternatively, if placement of a guide wire **300** into the physis

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is to be avoided, the guide wire **300** can be inserted proximally or distally off the physis and received through the corresponding proximal or distal end hole **112** of the bone plate **100**, as shown in FIG. **4A**.

Another guide wire **300** is inserted into the proximal drill guide **402**, as shown in FIG. **12**, and the bone is drilled with a cannulated drill bit **302** placed over the proximal guide wire **300**, as shown in FIG. **13**. An appropriately sized bone fastener **150** can be selected and passed over the guide wire **300** using a driver **320** engaging the head **152** of the bone fastener **150**, as shown in FIG. **14**.

The procedure can be repeated for the distal bone fastener **150**. A distal guide wire **300** can be inserted through the distal drill guide **402**, as shown in FIG. **15**, and the holding device **200** can be removed, as shown in FIG. **16**. A drill hole can be prepared for the distal bone fastener **150** with a drill bit **302** over the distal guide wire **300**, as shown in FIG. **17**, and the distal bone fastener **150** can be passed over the distal guide wire **300** and seated through the bone plate **100** into the tibia **90** with a driver **320**, as shown in FIG. **18**.

Although the implantation procedure is illustrated for the tibia, a bone plate **100** can be similarly placed on the femur, as shown in FIG. **8**. As can be seen from FIG. **8**, the initial placement of the bone fasteners **150** in each bone plate **100** can be such that the bone fasteners are substantially parallel or have a minimum amount of angulation to reduce the risk of breakage, as discussed above. The arched or stepped geometry of the bone plate **100** permits minimal contact with the lateral physis, as shown in FIG. **8**, and can reduce the risk of pressure necrosis.

Referring to FIGS. **19**, and **19A**, the bone plate **100** can be removed with the extractor **350** after the bone fasteners **150** have been unscrewed and removed with a driver **320**. The distal end **352** of the extractor **350** can include threads **354** engageable to the threaded inner surface **107** of the central hole **106** of the bone plate **100** for capturing and removing the bone plate **100**. The distal end **352** of the extractor **150** can have a cutting flute **356** for passing through fibrous soft tissue and a curved tip **358** defining a non-invasive radius for avoiding accidental damage to the physis.

The foregoing discussion discloses and describes merely exemplary arrangements of the present teachings. Furthermore, the mixing and matching of features, elements and/or functions between various embodiments is expressly contemplated herein, so that one of ordinary skill in the art would appreciate from this disclosure that features, elements and/or functions of one embodiment may be incorporated into another embodiment as appropriate, unless described otherwise above. Moreover, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. One skilled in the art will readily recognize from such discussion, and from the accompanying drawings and claims, that various changes, modifications and variations can be made therein without departing from the spirit and scope of the present teachings as defined in the following claims.

What is claimed is:

**1.** A growth control device comprising:

a bone plate having a stepped profile defined by a first level, a second level and an intermediate ramp connecting the first and second levels, the intermediate ramp being angled relative to the first level and the second level such that the first and second levels are vertically displaced from one another in separate planes, the first level including a first threaded hole for receiving a first bone fastener, the second level including a second threaded hole for receiving a second bone fastener, the bone plate

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including a proximal pair of side female notches, a distal pair of side female notches, a proximal guide hole and a distal guide hole; and

a holding device including first and second pivotably coupled arms, first and second legs extending from the corresponding first and second arms, a guiding bore defined between the first and second legs, and a curved split slot defined by a distal end of each of the first and second legs and shaped to receive one of a proximal end or a distal end of the bone plate, the split slot defining a split hole at a perimeter of the first and second legs so as to coextend with the guiding bore.

**2.** The growth control device of claim **1**, further comprising a guide wire, the guide wire passing through the guiding bore, through the split hole and through one of the proximal or distal holes of the bone plate, when the corresponding proximal or distal end of the bone plate is received in the split slot of the holding instrument.

**3.** The growth control device of claim **2**, further comprising a pair of male notches extending from a lower surface of the split slot perpendicularly to the lower surface such that one male notch of the pair of male notches is associated with each of the first and second legs, the pair of male notches shaped to be received in a corresponding one of the proximal or distal pair of female notches of the bone plate when the bone plate is held in the slit hole of the holding device, the proximal and distal notches being formed in an outer perimeter of the bone plate.

**4.** The growth control device of claim **3**, wherein the bone plate includes a threaded third hole through the intermediate ramp.

**5.** The growth control device of claim **4**, further comprising an extractor having a distal end threadably couplable to the third hole of the bone plate.

**6.** The growth control device of claim **3**, further comprising a targeting device including a support plate, a support post passing through the support plate and having a distal end threadably engageable with the third hole of the bone plate, and a tubular drill guide passing through the support plate and having a maximum angle of angulation of about 16 degrees relative to the support post, the drill guide couplable with any one of the first or second holes of the bone plate.

**7.** The growth control device of claim **1**, further comprising first and second washers unitarily integrated with the bone plate and surrounding the first and second holes on a bone engaging surface of the bone plate.

**8.** The growth control device of claim **7**, wherein the first and second washers include a lower surface spaced apart from the bone engaging surface of the bone plate.

**9.** The growth control device of claim **1**, further comprising first and second bone fasteners, each bone fastener having a substantially spherical head and capable of angulating relative to the bone plate when received through a corresponding first or second hole of the bone plate.

**10.** The growth control device of claim **1**, wherein a first horizontal plane extending through the first level is vertically spaced apart from a second horizontal plane extending through the second level.

**11.** The growth control device of claim **1**, wherein the proximal pair and the distal pair of side female notches are formed in an outer perimeter of the bone plate.

**12.** The growth control device of claim **1**, wherein a first portion of the curved split slot and a first portion of the split hole are defined by the distal end of the first leg, and a second portion of the curved split slot and a second portion of the split

hole are defined by the distal end of the second leg, the first and second legs cooperating to define the curved split slot and the split hole.

**13.** A growth control device comprising:

a bone plate having a stepped profile defined by a first level, a second level and an intermediate ramp connecting the first and second levels, the first level including a first threaded hole, the second level including a second threaded hole, the bone plate including a proximal pair of side female notches, a distal pair of side female notches, a proximal guide hole and a distal guide hole; first and second bone fasteners receivable in the first and second holes and angulatable relative to an axis substantially orthogonal to the bone plate within a cone of angulation; and

a holding device having first and second arms pivotable relative to one another, and first and second legs extending from the first and second arms, the first and second legs having first and second distal ends defining a curved split slot, a split hole and first and second male notches extending from a lower surface of the split slot, the first and second male notches associated with the respective first and second legs and engaging the first and second female notches when one of the proximal or distal ends of the bone plate is held in the curved split slot, the split hole formed in opposed exterior faces of the first and second legs.

**14.** The growth control device of claim **13**, further comprising a second bone plate having first and second threaded holes for bone fasteners and a third hole in an arched intermediate portion between the first and second holes.

**15.** The growth control device of claim **13**, further comprising a targeting device including a support plate having a plurality of openings, a support post passing through the support plate and having a distal end threadably engageable with the third hole of the bone plate, and a tubular drill guide passing through the support plate and having a maximum angle of angulation of about 16 degrees relative to the support post, the drill guide couplable with any one of the first or second holes of the bone plate.

**16.** The growth control device of claim **13**, further comprising a bone plate extractor, the extractor having a distal end including a threaded portion, a cutting flute and a curved tip with a non-invasive radius.

**17.** The growth control device of claim **13**, wherein the first and second holes define a substantially spherical surface.

**18.** The growth control device of claim **13**, wherein the first and second legs of the holding device are shaped to define a guiding bore terminating at the split hole defined at the distal ends of the first and second legs.

**19.** The growth control device of claim **18**, further comprising a guide wire passing through the guiding bore, the split hole, and one of the end holes of the bone plate when the bone plate is held by the split slot of the holding device.

**20.** The growth control device of claim **13**, wherein a first horizontal plane extending through the first level is vertically spaced apart from a second horizontal plane extending through the second level.

**21.** A growth control device comprising:

a plurality of bone plates of different sizes, each bone plate having first and second threaded holes and an intermediate portion between the first and second holes, the intermediate portion having a third threaded hole, the plurality of bone plates including at least one stepped bone plate having first and second levels connected by an intermediate portion in the form of an angled ramp such that the first and second levels are vertically displaced from one another in separate planes, and at least one arched bone plate having an intermediate portion in the form of a curved arch; and

a holding device including first and second pivotably coupled arms, first and second legs extending from the corresponding first and second arms, a guiding bore defined between the first and second legs, and a curved split slot defined by a distal end of the first and second legs and shaped to receive one of the proximal or distal ends of the bone plate, the split slot defining a split hole at a perimeter of the first and second legs so as to coextend with the guiding bore.

**22.** The growth control device of claim **21**, wherein each of the bone plates includes first and second washers unitarily attached to the bone plate and surrounding the first and second holes on a bone engaging surface of the bone plate.

**23.** The growth control device of claim **22**, further comprising a plurality of threaded bone fasteners, each bone fastener having a head, the head angulatably received within one of the first or second holes, such that a longitudinal axis of the bone fastener can form an angle in the range of about 0-16 degrees relative to an axis perpendicular to the bone plate.

**24.** The growth control device of claim **21**, wherein each bone plate includes a proximal pair of side female notches, a distal pair of side female notches, a proximal guide hole and a distal guide hole.

**25.** The growth control device of claim **21**, wherein the stepped bone plate is formed such that a first horizontal plane extending through the first level is vertically spaced apart from a second horizontal plane extending through the second level.

\* \* \* \* \*

UNITED STATES PATENT AND TRADEMARK OFFICE  
**CERTIFICATE OF CORRECTION**

PATENT NO. : 8,273,111 B2  
APPLICATION NO. : 12/166833  
DATED : September 25, 2012  
INVENTOR(S) : Matthew F. Amato et al.

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 2,

Line 6, replace “devices” with --device--

Column 4,

Line 40, replace “angle a” with --angle  $\alpha$ --

Column 4,

Line 52, replace “portions” with --portion--

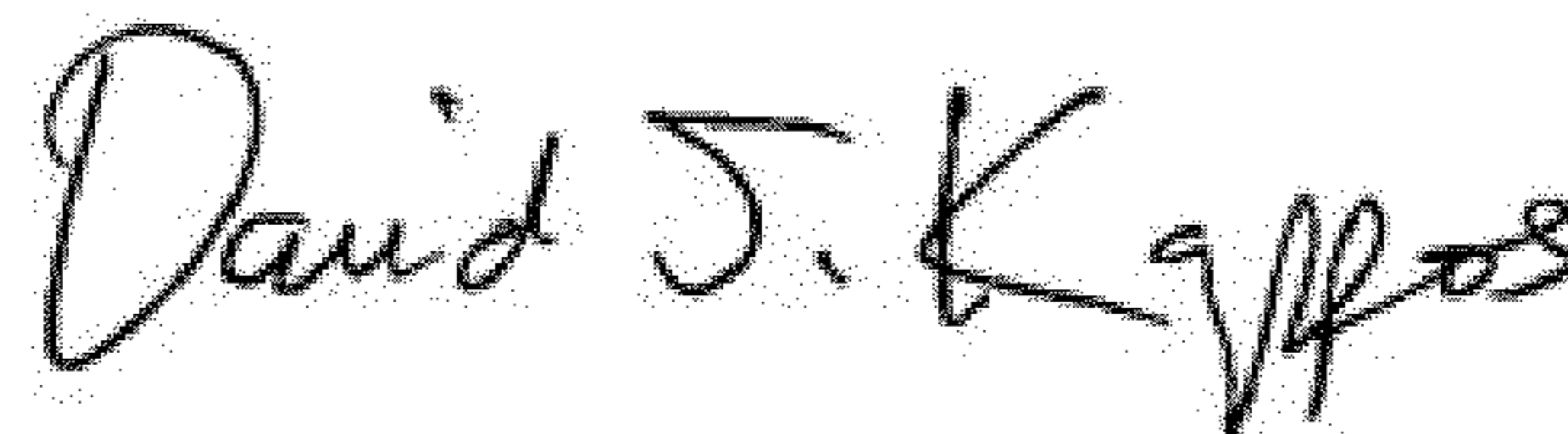
Column 5,

Line 1, after “can” insert --be--

Column 5,

Line 13, after “can” insert --be--

Signed and Sealed this  
Twentieth Day of November, 2012



David J. Kappos  
*Director of the United States Patent and Trademark Office*